DOCUMENT RESUME

ED 275 314 IR 012 376

TITLE The Computer: Extension of the Human Mind III. Proceedings of the Annual Summer Computer Conference (3rd, Eugene, Oregon, August 1-3, 1984).

INSTITUTION Oregon Univ., Eugene. Center for Advanced Technology in Education.

PUB DATE Aug 84

NOTE 162p.; For proceedings of conferences held in 1982, 1983, and 1985, see ED 219 859, ED 239 397, and ED 265 831.

AVAILABLE FROM Proceedings, Center for Advanced Technology in Education, 1787 Agate Street, University of Oregon, Eugene, OR 97403 ($10.00).

PUB TYPE Collected Works - Conference Proceedings (021) -- Viewpoints (120) -- Reports - Descriptive (141)

EDRS PRICE MF01 Plus Postage. PC Not Available from EDRS.

DESCRIPTORS *Cognitive Psychology; Computer Literacy; *Computer Uses in Education; Course Objectives; Elementary Secondary Education; Equal Education; Ethics; *Information Technology; Interactive Video; Local Area Networks; *Microcomputers; Public Policy; Recordkeeping; Research Reports; Special Education; Word Processing

ABSTRACT

The 13 conference presentations in this proceedings are arranged by general and special interest sessions and listed within each session in the order in which they were presented. These papers are: (1) "Key Issues for the Near Future" (David Moursund); (2) "Educating with Computers: Insights from Cognitive Psychology (and Video Games)" (Morton Ann Gernsbacher); (3) "Information Technology and Education: Public Policy and America's Future" (D. Linda Garcia and Fred W. Weingarten); (4) "Local Area Networks for Microcomputers in Education" (Philip K. Piele); (5) "Managing the Introduction of Computers into Education" (S. J. Thiessen); (6) "So What's a School District Computer Education Coordinator To Do?" (Greg Woods); (7) "Interactive Video and the Mentally Handicapped: A Research and Demonstration Program" (Philip Browning and Gary Nave); (8) "Overview of the Tri-County K-12 Computer Education Course Goals Collection" (Richard Ricketts); (9) "Equity Issues in Computer Use" (Sharon Franklin); (10) "Forget the Students, What Can Computers Do for Me?" (Richard C. Adams); (11) "Interactive Video in Education" (Ron Thorkildsen); (12) "Computing History to Use in Your Classroom" (Doris K. Lidtke); and (13) "Computers in Education Program Development at the District and Elementary School Level" (David Novick). Several of the papers provide references and/or additional sources of information. (DJR)

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THE COMPUTER: EXTENSION OF THE HUMAN MIND III

COLLEGE OF EDUCATION · UNIVERSITY OF OREGON
AUGUST 1, 2, 3, 1984

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PROCEEDINGS

The Computer: Extension of The Human Mind III

Third Annual Summer Computer Conference

Sponsored by

College of Education

University of Oregon

Held at the

Eugene Hilton and Convention Center

Eugene, Oregon

August 1-3, 1984

Published by the Center for Advanced Technology in Education

College of Education

University of Oregon

Eugene, Oregon 97403

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Preface

This is the third summer conference in this series sponsored by the University of Oregon College of Education. The special emphasis of the papers and presentations of this year's conference is on the educational aspects of computers in education. Understanding and using wisely the advanced technology now becoming available to us is a challenge worthy of any educator. We at the University of Oregon are pleased to be able to contribute to that understanding and appropriate use.

The conference is sponsored this year by the new Center for Advanced Technology in Education, recently established by the Oregon State Board of Higher Education. Four established College of Education programs are the foundation of the Center's activities: Instructional Technology Studies, ERIC Clearinghouse on Educational Management, Career Information System, and the International Council for Computers in Education.

In addition, CATE has the objectives of providing instruction in technological applications in education, researching the emerging technologies of education, and offering consultations, workshops, and seminars. A council of local and state educators will be advising on directions for the Center's development. We hope CATE will become an increasingly valuable service to you.

Primary roles in the organization of this conference were played by Gary Ferrington, conference coordinator; Bruce McKinlay, program chair; and Jude Ridge, registrar.

Robert D. Gilberts, Dean
College of Education

About CATE

The Center for Advanced Technology in Education (CATE) is a consortium of university-based, community, and state organizations with an interest in promoting the use of advanced technology in schools. The educational use of computers is a primary focus of the Center's activities.

Opened in the fall of 1983, CATE is the site of both preservice and inservice training for educators and a field-based research and development program investigating a variety of advanced and interactive instructional technologies and their implications.

Members of the CATE Council and the CATE network are widely scattered across Oregon. They include school districts, state colleges, community colleges, extension services, and the State Department of Education. Housed in the CATE facility at 1787 Agate is the ERIC (Educational Resources Information Center) Clearinghouse on Educational Management, the International Council for Computers in Education (ICCE), the Instructional Technology (IT) Laboratories, and the Career Information System (CIS). There are also a resource library and facilities for classes and workshops on the use of computers in education.

For more information about CATE or a copy of the CATE newsletter, Advance, write to Editor, Advance, Center for Advanced Technology in Education, 1787 Agate, Eugene, Oregon, 97403.

About The Proceedings

The Center for Advanced Technology in Education (CATE) is pleased to offer this printed proceedings of the Third Annual Summer Conference on The Computer: Extension of the Human Mind, sponsored by the College of Education at the University of Oregon and held in Eugene, Oregon, August 1-3, 1984.

Appreciation is due the conference presenters for their promptness in meeting deadlines so that the proceedings might become a reality. Grouped according to general and special interest sessions, the papers are listed within each session in the order in which they were presented. To meet our publication deadline and control printing costs, the papers are presented exactly as they were received.

The authors of these papers were invited to make presentations at this conference because of their acknowledged scholarly or professional competence in some aspect of computers and education. The findings, views, or opinions expressed by those authors, however, are entirely their own and do not necessarily represent those of CATE, the College of Education, or the University of Oregon.

Additional copies of the proceedings may be obtained by sending $10.00 (prepaid or purchase order) to Proceedings, Center for Advanced Technology in Education, 1787 Agate Street, University of Oregon, Eugene, Oregon, 97403. Checks should be made payable to CATE.

Foreword

From any perspective--technological, economic, or social--the microcomputer is an unexpected and powerful innovation that may indeed earn the label "revolution." The speed at which it is becoming an accepted personal tool has caught most institutions by surprise. As impressed as one may be with the microcomputer itself, there is also good reason to be impressed with the capacity of people in our much-maligned schools to find good educational uses for it and to grasp the implications of its widespread acceptance.

The people whose papers appear in this volume are practitioners and scholars whose work is turning the microcomputer from just an impressive technological innovation into a useful educational tool. As with any adventure, the thinking and work they describe for us shows a mix of excitement and scepticism. There are not many textbook answers here, but there is clear evidence of responsible educators coming to grips with the potential of this new device.

Microcomputer Technology

With some cautious speculation about the next decade, David Moursund provides a useful reminder that what we have seen in the recent past will continue. Storage will continue to get cheaper and processing will continue to go faster.

Two technological developments are potentially very important for education in the near term--the linking of microcomputer components in local area networks and the linking of computer and video components. Philip Piele describes the rapid change now taking place in the area of local area networks for microcomputers, which he studied during his recently completed sabbatical as a visiting scholar at Stanford University.

When words, pictures, and user control can be combined, the resulting technology has obvious educational value. Philip Browning and Gary Nave report on computer-assisted video instruction, and Ron Thorkildsen describes the components and use of videodisk technology.

As useful as the descriptions of technology are, the important thing about these papers is the perspective that these authors bring to the educational dimensions of their work. Moursund relates the technological trends to the instructional uses of computers; Piele reports the limitations as well as the potential of networks and provides cautions for all of us; while Browning, Nave, and Thorkildsen discuss the use of computer and video components with some of our most deserving students--those in special education.

Educational Issues

The question educators are asking about computers is no longer merely "What is it?" They are also asking about its educational value and the social implications of its integration into the educational process. These are the dominant issues addressed in the papers--How can the computer be used effectively? and What does it mean to do so? Nearly every paper shows thoughtful consideration of both questions.

We asked Morton Ann Gernsbacher to review the research on cognitive psychology and tell us what lessons it has for teaching with computers. Her paper talks about learning, with clear messages about how we can use computers to improve the process. Richard Adams reveals how individual teachers can gain some control of their time with productivity tools such as word processors and record keeping programs. Dick Ricketts provides an overview of computer education course goals, while Doris Lidtke suggests ways to incorporate interesting bits of computing history in instruction. Greg Woods, Jack Turner, and S. J. Thiessen all provide valuable information and insight into the educational impact of computers on schools and school districts. From the broadest policy perspective, D. Linda Garcia and Fred Weingarten report the findings of the Congressional Office of Technology Assessment's major study of information technology and education, raising questions and suggesting where answers may lie.

Two of the major societal questions about the impact of computers in education are addressed explicitly. To help answer the serious equity question--"Will everyone benefit?"--Sharon Franklin draws together evidence and practical suggestions from the excellent special issue of The Computing Teacher on equity.

Many wonder what value we place on information when software piracy deprives people of their intellectual property. David Novick, an attorney and computer scientist, addresses these ethical questions.

Whatever their subjects and however they address them, these authors show that there is significant knowledge of important topics concerning computers and education. These papers provide useful information and advice, and they show a sensitivity and serious concern for the broadest educational and social issues.

Bruce McKinlay
Program Chair
The Computer: Extension
of the Human Mind III

Contents

		Page
	GENERAL SESSIONS	1
1.	*Key Issues for the Near Future* David Moursund Professor of Computer Science University of Oregon	3
2.	*Educating with Computers: Insights from Cognitive Psychology (and Video Games)* Morton Ann Gernsbacher Assistant Professor of Psychology University of Oregon	18
3.	*Information Technology and Education: Public Policy and America's Future* D. Linda Garcia Senior Analyst Fred W. Weingarten Program Manager Communications and Information Technologies Program Office of Technology Assessment U.S. Congress, Washington, D.C.	45
4.	*Local Area Networks for Microcomputers in Education* Philip K. Piele Professor and Director ERIC Clearinghouse on Educational Management University of Oregon	62
5.	*Managing the Introduction of Computers into Education* S. J. Thiessen Director, Computer Technology Project Alberta Education	74
	SPECIAL INTEREST SESSIONS	
6.	*"So What's a School District Computer Education Coordinator To Do?"* Greg Woods Computer Coordinator Klamath County School District	84

Page

7. *Interactive Video and the Mentally Handicapped: A Research and Demonstration Program* 90
Philip Browning
Gary Nave
Rehabilitation Research and Training Center
University of Oregon

8. *Overview of the Tri-County K-12 Computer Education Course Goals Collection* 102
Richard Ricketts
Managing Editor
The Computing Teacher

9. *Equity Issues in Computer Use* 109
Sharon Franklin
Editor
The Computing Teacher

10. *Forget the Students, What Can Computers Do For Me?* 117
Richard C. Adams
Pleasant Hill High School

11. *Interactive Video in Education* 125
Ron Thorkildsen
Utah State University

12. *Computing History to Use in Your Classroom* 133
Doris K. Lidtke
National Science Foundation
Washington, D.C.

13. *Computers in Education Program Development at the District and Elementary School Level* 140
David Novick
Computer and Information Science
University of Oregon

GENERAL SESSIONS

KEY ISSUES FOR THE NEAR FUTURE

David Moursund
International Council for Computers in Education
1787 Agate Street
Eugene, Oregon 97403

Computers are a change agent in education as well as in business, industry and people's everyday lives. In business and industry it is clear that computers can lead to increased productivity and a competitive advantage. Computers in telecommunication systems and consumer items may improve the quality of these services and goods. But it is not at all clear that computers are improving or necessarily will improve education. In this paper we examine certain aspects of computers in education and what may happen in the near future. We are looking for ways to improve education.

Let's begin by defining the "near future" to be the next decade. In this paper we explore some of the potentials of computers for the next ten years. These potentials raise a number of key issues that education must face.

The first part of this paper discusses computer capabilities that are apt to be readily available during the next decade. Here we are not interested in futuristic speculation. Rather, we discuss products and services that are just now becoming available or have proven themselves in research labs. These are apt to be readily and cheaply available within the time span we

are calling the near future.

The second part of this paper is specifically geared to education. It examines the major instructional uses of computers and relates them to the progress discussed in the first part of the paper.

The third part addresses some key issues and contains speculation about whether computers will help to improve our educational system. It includes suggestions of what needs to be done to increase the likelihood that computers will help improve education.

Part I: The Next Decade

IBM recently announced that it has developed a process to produce one megabit memory chips that uses the same type of manufacturing equipment currently producing 64K memory chips. This is very important both because it says that researchers know how to produce a one megabit memory chip and because it will not require expensive new equipment to manufacture such chips. Several Japanese companies have already announced that they expect to begin selling one megabit memory chips in 1986.

One megabit is 128K bytes -- more memory than is found in most of today's microcomputers. Ten years from now a megabit chip will be old technology. The retail price of such a chip

might be about $5 (in 1984 dollars). A middle-priced microcomputer (such as today's $1,000 machine) will likely contain one or two megabytes of primary memory in 1994.

Although the 8-bit central processing unit is still most common, 16-bit CPUs are widely used and several companies produce single chip 32-bit CPUs. The trend here is evident. The middle-priced microcomputer of 1994 will have a 32-bit CPU that is quite fast. IBM, for example, recently announced that it had developed a chip capable of performing 100 million multiplications per second.

Changes in magnetic disk technology have been quite steady and predictable. The 8 inch floppy led to the 5 1/4 inch floppy and now we have 3 1/2 inch disks. Storage capacity has gradually increased. Perhaps the next big step will be the successful commercial production of disks using vertical storage. In vertical storage the magnetic domains are alligned vertically rather than horizontally in the plane of the disk. Storage capacity gains by a factor of between 10 and 100 are claimed. Meanwhile, hard disks are continuing to increase in storage capacity and decrease in price.

The continued progress in magnetic disk technology suggests that by 1994 the middle-priced microcomputer will have a disk drive with several megabytes of capacity. Microcomputers equipped with 40 megabytes or so of hard disk capacity will be

common.

We are just beginning to see a proliferation of relatively inexpensive hand-held, battery powered microcomputers with full sized keyboards. These were introduced in the United States less than two years ago at a starting price of about $800. Now the starting price has dropped by $200 and newer, better models are appearing. The trend here is also evident. Such machines are easily mass produced and mass marketed. They come with some useful built-in applications software and communications facilities. By 1994 one might expect such machines to have far more capability than today's typical 8-bit desktop microcomputer but sell for $200 (1984 dollars). A wide range of applications software will be built into the machine. Hewlett-Packard, for example, has Lotus 1-2-3 on a chip in one of its new hand-held microcomputers.

We could continue the hardware projections. Electronically erasable programmable read only memory and bubble memory will both make giant strides. Laser disc secondary storage systems will be common. Flat screen displays with high resolution graphics will be common. Tape storage capacity continues to grow while reliability is increased. The main point is that we can expect continued rapid hardware progress, much like we have seen in the past decade. Such progress will allow use to provide every student with a personal computer.

Software progress never appears as dynamic as hardware progress, but viewed over a period of years the progress is impressive. In this paper we will briefly discuss three trends.

First, consider high level programming languages. Fortran, COBOL and BASIC have been with us for 20 to 30 years. The installed base is very large. The term "installed base" refers to a combination of software, manuals and books, and trained people. It is evident that Fortran, COBOL and BASIC will still be widely used ten years from now.

Pascal and Logo are two more recent successful languages. These will continue to grow in stature. Many still newer languages are used, and still others will be developed. But the idea of an installed base is important. For example, it would surprise me to see more than one newer or new language have any significant impact at the precollege level over the next decade. Ada will gradually gain a foothold in higher education and in military/industrial applications.

The second aspect of software to watch is the user-friendly application packages that have made such great strides in recent years. Even on an ordinary microcomputer one can have a good word processor with spelling and grammar checker, a graphics package, electronic spreadsheet, a database system and so on. Already these are beginning to be available in integrated packages that make use of display screen windows as well as touch

screen or mouse. I believe the trend here is evident. The number of applications that are integrated into a single package will continue to grow. The user friendliness will increase and the price will decrease. The middle-priced microcomputer of 1994 will include a very substantial package of such software. On many machines this will be built in as firmware.

We will also see great strides in making more specialized packages available to users. The hugh mathematical and statistical libraries now available on mainframe machines will all run on the middle-priced microcomputer of 1994. There are literally billions of dollars of currently available software that will function adequately on the type of desktop and portable microcomputers that will be readily available.

The third aspect of software that will be interesting to watch is that connected with artificial intelligence. The field of AI has made steady progress and is now producing commercially viable products. Most of these products are expensive and in limited use -- partly because they typically require a relatively fast 32-bit CPU machine with several megabytes of primary storage. But that is exactly what we are projecting will be the middle-priced microcomputer of 1994. Thus, we can expect that AI will gradually enter our everyday lives, especially on the job. Progress will continue to be gradual, but the cummulative results will be impressive.

Besides general hardware and software there is one additional very important part of the computer future. It is telecommunications. The current installed base, including telephone equipment and telephone users, is very large. But the potential of linking all homes via fiber optics or other high capacity switchable links, and providing all homes with a terminal, will be steadily achieved. This will provide easy access to data banks, bulletin boards, electronic mail, electronic conferencing and all kinds of other useful applications. Cellular radio is just beginning rapid expansion: in a decade people will routinely use such portable phone equipment. Videophones have been available for quite some time; fiber optic connections into people's homes will make videophones economically practical. To summarize, it is evident that substantial progress will occur over the next ten years as more and more people come to appreciate the benefits of having easy access to a giagantic computerized telecommunications network.

Part II: Computers in Instruction

Instructional uses of computers fall into three main categories.

1. Learning about computers: The study of computer and information science and its applications.

2. Learning using computers: All aspects of using computers as

an aid to learning and instruction.

3. Learning incorporating computers: Here the computer is considered as an everyday tool integrated into the curriculum; it is a general aid to problem solving and an integeral component of the content of each discipline.

In higher education the computer and information science curriculum throughout the country is becoming reasonably standardized. We can expect this trend to continue, just as it has in other older disciplines. The Advanced Placement test in computer science will help standardize the college freshman year sequence in this field.

The teaching of computer applications in higher education is in turmoil. Demand for courses is growing rapidly as more and more students own a microcomputer. Who should teach the courses and what should be taught is not clear. The next decade will likely see us well along to resolving this difficulity. The ready availability of good computer hardware and software will likely lead to widespread integration of computer-oriented instruction into courses taught outside the computer and information science departments.

At the precollege levels we still don't really know what we are doing in terms of teaching about computers. The Advanced Placement test merely suggests that what higher education is

doing is also appropriate for a modest number, perhaps a few percent, of high school students.

People talk about computer literacy and there have been numerous recommendations that all students should have a half-year computer course. Many middle schools and junior high schools have implemented a half-year computer programming course. It seems likely that this trend will continue even as a different approach gains strength. The learning of computer applications will eventually be the dominant component of computer literacy. Students will learn word processing, computerized information retrieval and use of graphics packages. Eventually the use of very sophisticated application packages will be integrated into the everyday curriculum at every grade level.

Ten years will probably not be long enough to resolve the question as to what precollege students should learn about computers or when they should learn it. Part of the difficulity is that even ten years from now we will not fully understand the third component of computers in instruction, learning incorporating computers. We will return to that topic after discussing learning using computers.

Although computer-assisted learning (CAL) is perhaps thirty years old, it is just beginning to emerge from its infancy. We now have solid evidence that CAL is educationally sound in a variety of settings. But to a large extent it has not been cost

effective in the past, and there has been only a very limited amount of reasonable quality software.

The next decade will go far toward solving both of these problems. The hardware will be available and there will be much more and much better software. Traditional education at the precollege and college levels will face an increasing challenge of home education, education in the workplace and in other non-traditional educational settings.

The potential of videodiscs in CAL is reasonably well understood, but videodiscs are not yet a significant factor in education. Ten years from now videodiscs will be common in education. Many entire courses will be available in a CAL-videodisc format. This may begin to create a substantial amount of competition in precollege education.

The increasing availability of good quality, cost effective CAL will be a challenge to school boards, school administrators and teachers. We will likely see labor unrest much as we have seen in newspaper and other companies that have installed computers. Certainly the role of many teachers will gradually need to change. This change will take far longer than ten years, however.

I believe that learning incorporating computers is a still bigger challenge. Here we must still resort to analogies to even

begin to understand the challenge. Consider for a moment how dependent our educational system is upon books, pencil and paper. To a large extent the very fabric of our educational system is woven into these aids to learning and information processing. Now we have a new aid that incorporates ideas from books, pencil and paper, but is much more. What is it like to have one's first writing instruction in a word processing environment where one has a spelling checker and a grammar checker? What should a mathematics curriculum look like when all students have ready access to computer graphics, equation solvers, algebraic symbol manipulation systems and so on? What information retrieval and communication skills are appropriate when computerized information retrieval and telecommunication systems are readily available? How should computerized artist aids and music composition aids affect instruction?

The list can be lengthened, and the problem is further confused by progress in artificial intelligence. If a computer can solve or substantially help in solving a particular general category of problems, what should students learn to do unaided by the computer?

And once again we see a major challenge to teachers. For example, suppose that a decision is made to allow all students to use calculators and computers as an aid in doing mathematics whenever they like after they have completed traditional third grade arithmetic. The majority of teachers in grades 4-6 would

be at a loss as to how to make effective use of the mathematics instruction time available in their classrooms. Algebra courses would need to be completely redesigned.

Part III: Key Issues

There is no doubt that education will be profoundly affected by computers. The key issue is whether this affect will be positive or negative.

Let's first examine what might be considered a potential positive affect. Research over the years has provided us with considerable knowledge about teaching and learning that is not incorporated into instructional materials or teacher behavior. CAL-videodisc provides a method of packaging what we know about teaching and learning theory in a format that is directly accessible by students. This type of instructional/learning medium lends itself to long term formative evaluation, and thus to continued improvement. We already have solid evidence that students can learn faster and better from such CAL, as compared to conventional instruction.

One can imagine a future in which the federal government invests a half billion dollars a year in the development and continued improvement of high quality, research-based CAL materials. Note that this figure is well under a half of one percent of what is spent yearly on precollege education in the

United States, and is under five percent of what the federal government spends on precollege education.

Such a concentration of research and development funds could easily produce a hundred full length high quality high school or college courses per year. The Open University in England gives us some insight into possible results. There the government has paid for the development of high quality courses delivered via television. This has allowed many people to pursue a college degree who might not otherwise have been able to, and it has also led to an improvement in the quality of courses taught by colleges and universities.

Right now our educational system has relatively little competition. The type and quantity of CAL mentioned above would constitute substantial competition for our traditional educational system. Such competition could well lead to changes that result in improved education for students.

Now consider a more negative scenario. It is almost mind boggling to watch a secretary who is well trained in use of modern computerized aids. Both the tasks to be performed and the necessary skills are quite different from what one finds in a non-computerized office.

Most secondary schools and community colleges offer an office-practices course of study. These have been slow to

change. One can imagine that ten years from now many schools will still be offering an office-practices curriculum that is only modestly changed from what is now offered. This could occur because the installed base of equipment, teacher knowledge and texts is quite large.

Actually it is quite unfair to use business curriculum teachers as an example. They are apt to succeed far better than teachers in other disciplines in adjusting to computers. Instead let's look at math teachers for a moment. The potential for change in the math curriculum is hugh. But the installed base may overwhelm this potential for change. What does a math teacher do who cannot spend most of the time teaching routine arithmetic and algebraic computation? What do students do if math seatwork does not consist of thirty nearly identical computations or routine symbol manipulations to perform?

The length limitations on this paper preclude examining other disciplines in detail. Ten years from now high school science labs may still be used for historical recreations as they often are today, or they may make considerable use of the computerized instrumentation found in modern industrial and research labs. Social studies and history courses may be fact memorization-oriented as they are today, or may become problem-solving courses that make use of modern information retrieval and communication systems. Ten years from now static textbooks may still be the dominant source of content and focus

of student attention, or we may begin to see the signs of significant change. It will be interesting to see what happens.

A growing and well-founded fear is that educational progress will not be uniform. Richer school districts and righer parents will be able to provide adequate computer facilities and adequate teacher training support to implement substantial changes. Other school systems will remain stuck in their current ruts. Equity will definitely be a live issue during the next decade.

This paper began by indicating that computers are a change agent in education. We know lots of ways to make education better, and many do not require computers. But education is a massive system and is highly resistant to change. Computers will continue to be a change agent for many years to come, but eventually will be assimilated into our everyday way of life.

That leads to my final remarks. No matter what progress technology can contribute to education in the next decade or two, the key to quality education will still be quality teachers. We must provide appropriate growth and learning opportunities for current teachers. We must learn to reward good teachers and to attract more potentially high quality teachers into the profession. Computers will be important in education. But people are and will remain far more important.

Educating with Computers: Insights from Cognitive Psychology (and Video Games)

Morton Ann Gernsbacher
University of Oregon

History claims that the roots of computerized instruction can be traced back more than sixty years. In 1920, at the Ohio State University, S. L. Pressey introduced the prototypic "teaching machine." However, Pressey's state-of-the-art invention received only a nonchalant glance from the educational system of his day (Hintzman, 1977). It was nearly thirty-five years later before such technology was seriously considered as a potential classroom asset. This second and significantly more serious look was motivated by one of the teaching machine's most powerful advocates, B. F. Skinner. Indeed, in his 1954 Harvard Educational Review address, Skinner promised that teaching machines and their related technology were ready to carry education over the "threshold of an exciting and revolutionary period" (Skinner, 1954, p. 97). Unfortunately the metaphorical marriage ended unhappily. Evaluative research indicated that learning via machines failed to beat the effectiveness of leaning via texts written in the same programmed format. Moreover, in some situations, those programmed texts failed to match the effectiveness of competent teachers (Hilgard & Bower, 1966). Considering the costs of the new-fangled-but-no-more-effective teaching machines, it seemed more reasonable to stick with the traditional media.

Anyone who has not been hidden under a rock or in a Rip van Winkle like state is aware of the current rise in technology. Now, nearly three decades later, we are again on the forefront of a technological frontier. To parrot a well worn phrase, we are entering the Computer Age. Today's computers are faster, cheaper, larger in memory, smaller in physical size, and more powerful than the inventors of their ancestral machines ever envisaged. It is claimed that with the aid of today's computers one can do most everything -- from balancing a checkbook to composing a symphony -- better than ever before. But will today's computers also provide better tools for education? That is, will today's computers make good the promisory notes offered by yesterday's technology?

I will argue strongly that the answer is yes. This is because today, along with our micros and minis, RAMs and ROMs, integrated circuits and silicon chips, we have two other whetstones upon which to sharpen the computer as a tool for education. The first whetstone derives from the empirical advances made by a relatively new field called Cognitive Psychology. Research conducted in cognitive psychology laboratories across the country has illuminated quite a bit about how humans process information; this research can now be codified into principles which are ripe for application in teaching and its interface with computers. The second whetstone derives from

an observation in the real world: Computer-based video games are overwhelmingly attractive and perhaps even addicting. Not only has their current popularity demonstrated that computers are not the spooky machines we once imagined, perhaps when encountering our first inconvenience due to a mix-up on a computerized utility account. Rather, to many of today's youth, computers (at least the ones that empower Pac Man and Space Invaders) are as non-threatening, commonplace, and desirable a machine as a telephone. Even more important, the process of mastering the skill required to play computerized video games demonstrates many of the theoretical principles proposed by cognitive psychology to underlie skill development in general. For these reasons, my thesis here will be that both these contemporary developments (though primarily the former) provide important implications for the role that today's computers can play in today's educational system.

The Focus of Contemporary Cognitive Psychology

Let me begin by describing the focus of contemporary cognitive psychology. Cognitive psychologists are interested in the scientific study of "'higher mental processes' including memory, perception, learning, thinking, reasoning, language, and understanding" (Lachman, Lachman, & Butterfield, 1979, p. 6). Surely fervent interest in this topic has existed for several centuries. No doubt, even before the days of Aristotle and Plato, humans sought to unravel the nature of the mechanism we call the mind. However, scientific investigation into human thought was not approached until experimental psychology per se emerged as a discipline in the late nineteenth century. And though the workings of the human mind was hearty grist for those early investigators' mill, the topic did not sustain scientific inquiry too far past the turn of the century.

Two interdependent factors led to rejecting the human mind as a suitable research focus. First, the early investigations had been plagued by a lack of methodological sophistication. Their primary methodology was introspection, observing and reporting one's own mental activities. Despite the elaborate training and scoring procedures accompanying it, introspection fell shy of the rigor demanded of a laboratory tool. The second coffin nail was hammered in during the 1920s. During that decade, American psychology experienced a far reaching and dramatic theoretical revolution. The movement was toward a radical perspective, a perspective that virtually shunned the study of the human mind. The perspective was known as Behaviorism.

According to Behaviorism, all behavior could be understood in terms of external stimuli evoking conditioned responses. Indeed, stimuli and responses were believed to be so primary to explaining behavior that behaviorism came to be known as S-R psychology. Furthermore, the link between stimuli and responses was assumed to be so tight, so direct, so explicit, that it was inconceivable to behaviorists that any mental mediation ever occurred. For the behaviorists, simply believing in mental

mediation was tantamount to believing in medieval witchcraft (Watson, 1930).

In its heyday, behaviorism was absorbed into many of its related disciplines; American education was a prime sponge. Learning, according to the behaviorists, constituted simply increasing the strength of the link between a stimulus and its optimal response. Ergo, any technique that promised to increase the strength of this link or what Hull (1943) called the "habit strength" would be just what the doctor ordered. It was from this theoretical premise that Skinner so strongly advocated bringing teaching machines into the classroom.

I will end this brief historical tour here. Suffice it to say that for a collection of factors -- foremost being that the behaviors observed in the behaviorists' own laboratories failed to match up to their theoretical predictions -- behaviorism soon lost its stronghold. Similarly, for another handful of factors a new field emerged. This new field prescribed investigation into previously taboo domains: mental structures and mental processes. This new field promoted a new definition of learning: the process of acquiring, retaining, and retrieving knowledge. And this new field heralded a novel name: Cognitive Psychology. Indeed, the word cognitive itself means knowledge, and the processes that underlie how people manipulate knowledge is the focus of contemporary cognitive psychology. Moreover, implicit in this approach is the tenet that internal, mental processes can, do, in fact, must, mediate the learning.

This new approach provides the impetus for the optimism I expressed earlier. That is, when technology was invited into the classroom during the 1950s, I believe it was subsequently ushered out primarily because it was based on an erroneous conception of learning. However, in the 1980s when the invitation is extended again, I believe the movement will be fruitful if the based on some of the principles of contemporary cognitive psychology.

A Framework for Understanding Cognition

As as I just mentioned, the goal of cognitive psychology is understanding the processes that occur when people manipulate knowledge. It has become convenient to talk about these processes by categorizing them into three basic types: Encoding (how information is acquired into the mind), Representation (how information is retained or stored in the mind), and Retrieval (how information is accessed or retrieved from the mind).

In addition, it is also convenient to talk about the types of knowledge people manipulate by categorizing them. At first blush, such a task might seem rather cumbersome. Surely, over the span of a hour's lecture, a year long course, or a lifetime one manipulates all different types of knowledge. For example, most of us have previously encoded and therefore have mentally represented knowledge about who the first U.S. president was, how to endorse a check, where our cars are parked, or the dates of our spouse's birthdays (although perhaps we sometimes have difficulty retrieving the last two bits of information). Just

these examples appear to encompass an array of knowledge. However, a useful but simple dichotomy has been offered by John Anderson, a cognitive psychologist at Carnegie-Mellon. According to Anderson (1976), knowledge is either declarative -- information about what something is -- or procedural -- information about how to do something. Knowing where your car is parked is an example of declarative knowledge; knowing how to drive it home is an example of procedural knowledge. Thus, the dichotomy is basically the distinction between knowing <u>that</u> versus knowing <u>how.</u>

This dichotomy of types of knowledge maps nicely onto what I see is a similar dichotomy: the two major roles that computers can play in the classroom. On the one hand, there is learning by computers, i.e., computer-based or computer-assisted instruction. In this role, computers are used for helping students manipulate declarative knowledge. On the other hand, there is learning how to program computers. In this role, computers are the vehicles that students use to manipulate procedural knowledge.

These two dichotomies and their one-to-one mapping form the outline for the remainder of this paper. In the next section, I will describe what we know about manipulating declarative knowledge and speculate briefly about how computers can aid in this endeavor. In the second section, I will describe what we know about manipulating procedural knowledge. There I will offer some suggestions about how to facilitate these processes when the particular content of procedural knowledge is computer programming skill. In both sections, I will begin by summarizing the primary theoretical positions and reviewing the major empirical research that these theories either motivated or were deduced from. And in both sections, I will end by briefly commenting about how video games illustrate many of these major principles.

Processes Involved in Manipulating Declarative Knowledge

My discussion of what is currently known about how declarative knowledge is manipulated will be organized around the three major processes I introduced earlier, namely, encoding, representation, and retrieval. I will deal first with representation, then retrieval, then encoding. I have chosen this order for a couple of reasons. First, though the theoretical conception of each of the three processes holds direct ramifications for the conceptions of the other, representation somewhat dictates to the remaining two. The situation is much like the fact that how one's money is represented (francs, yens, C.O.s, gold, or wooden nickels) somewhat directs how one can go about retrieving it from or putting it in a suitable place of storage. The second reason I have chosen this order is that it will help build my discussion toward the last two processes that I believe hold the strongest interest to educators and provide the most direct implications for computer-based learning.

The Representation of Declarative Knowledge

Cognitive psychologists (or anyone for that matter) cannot precisely specify how information is stored or represented in the mind to the extent that one can specify the inner workings of an automobile engine. For ethical reasons, they cannot invite subjects into their labs and then surgically open up their brains for a peek inside. Even if they could, it would be for naught. All that they would see would be a collection of neural structures, billions of cells connected by masses of tissue. Where or how the knowledge was represented that, for instance, their subject possessed about his or her grandmother would still be a mystery. Instead, what cognitive psychologists do is conduct relatively unobtrusive experiments and from the results of those experiments infer what properties likely exist.

One of my graduate school professors suggested the following analogy: Cognitive psychologists seeking to understand the nature of mental structures and processes are in the same boat as a spy yearning to learn about the workings of a competitor's production factory, say a General Motors plant, but is barred from entry. The spy's only recourse is to carefully monitor what goes in and scrutinize what comes out. From comparing the input materials with the output products, she must extricate what processes were likely to have occurred inside the plant. Thus, in the experiments cognitive psychologists conduct, they go to great pains to control the input (the knowledge subjects are expected to encode) and equally great pains to measure the output (the knowledge subjects retrieve). Then they compare the results of their experiments with the results of similar ones conducted by other cognitive psychologists in the same fashion that spies would exchange information to see if their reports concurred. Fortunately, during twenty years of research numerous reports have concurred and several fundamental principles can be gleaned from them about how knowledge is mentally represented.

First, it is clear that knowledge is not mentally stored in a random or haphazard fashion; instead, it is systematically organized. Consider the results of a classic experiment by Bousfield (1953). Subjects were given a list of 60 nouns to remember, and these 60 nouns fell into four different semantic categories: animals (e.g., giraffe, chipmunk, badger), male first names (e.g., Gerald, Wallace, Simon), professions (e.g., milkman, broker, chemist), and vegetables (e.g., spinach, mushroom, brocolli). When the nouns were presented to the subjects they had been arranged in a thoroughly random order. However, when the subjects were later required to retrieve the nouns, they recalled them in a systematically organized fashion; they recalled the nouns that belonged to each category as a group. The results from this experiment, as well as countless others that have replicated them (provided identical results), suggest that unlike a patchwork quilt there is a rhyme and reason underlying the organization of information in the mind.

In addition, it is clear that knowledge is not mentally stored as separate isolated swatches of information; rather it is

stored with rich interconnections between related concepts. Another, now classic, experiment by Meyer and Schvaneveldt (1971) nicely illustrated this principle. Their experiment utilized a laboratory task known as lexical decision. In this task, subjects are presented with letter strings (e.g., BREAD) and required to decide as rapidly as possible whether each letter string composes an actual English word. (To keep subjects honest, on half the trials the letter strings do indeed form "real" words while on the remainder they do not.) Obviously, this is a relatively easy task for most undergraduate psychology students and accuracy usually hovers around 100%. However, accuracy is not the primary measure of performance in the lexical decision task; the more interesting measure is the subjects' speed in making each decision. Two assumptions underlie the use of this task: making the decision necessitates retrieving the approriate information, (accessing the mental representation for the word, BREAD); and the time required to make the decision indicates the relative ease with which the mental representation can be accessed.

In the Meyer and Schvaneveldt (1971) experiment, subjects were required to make lexical decisions to pairs of letter strings presented simultaneously. On some trials both members of a pair were words, on some trials neither member was a word, and in the remainder of the trials only one member of a pair was a word. More importantly, on half the trials where both members were words, the words were semantically related to each other (e.g., BREAD and BUTTER; or NURSE and DOCTOR) while on the other trials where both members were words, the words were not semantically related (e.g., BREAD and DOCTOR; or NURSE and BUTTER). Subjects' lexical decisions were, on the average, 35 milliseconds faster when the words were related than when they were not. The results from this experiment, as well as countless others which have replicated them, suggest that information is mentally represented via facilitative interconnections. In other words, it is likely that there are connections between the mental representation of "bread" and the mental representation of "butter" such that accessing the first facilitates accessing the second.

Thus, any viable conception of how declarative knowledge is mentally represented must stipulate a representation scheme that emphasizes organization and incorporates interconnections among represented concepts. One popular conception that fits this bill is the proposal that declarative knowledge is represented via a system of networks (Anderson & Bower, 1973; Anderson, 1976; Lindsay & Norman, 1977; Norman & Rumelhart, 1975; Quillian, 1969, Wickelgren, 1976). These networks are made up of nodes where each node represents a concept. The nodes are interconnected by pathways.

Consider Figure 1 below. It depicts a hypothetical network representation and is modelled after a figure presented by Collins and Loftus (1975). In this figure, nodes are depicted as elipses; their interconnecting pathways are depicted as lines. In the center is a node representing the concept "bread". Presumably, most closely related to "bread" are the concepts,

"butter," "sandwich," "crust," some popular brands of bread, some of its well known ingredients, and perhaps some familiar types. More distantly related are the concepts "money," "potatoes" and other types of starches. Each of these concepts are additionally related to other concepts that may or may not be interconnected to the core concept "bread." This figure is only intended to be a schematic depiction of a hypothetical memorial network; no claim is being made that this is the literal way that declarative information is represented neurally or that these concepts would be related in the same way for each individual.

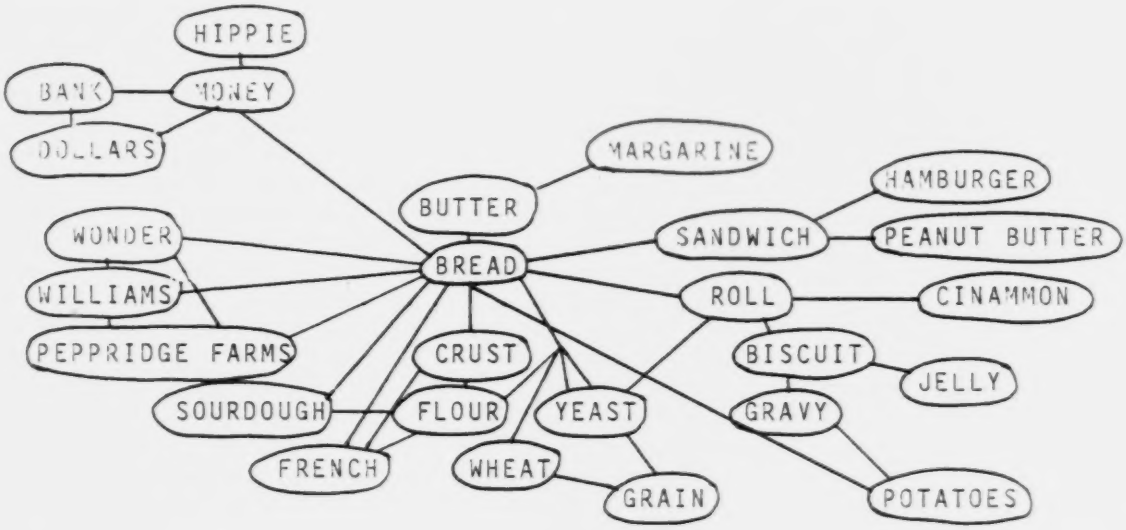

Figure 1. A hypothetical memory representation network surrounding the core concept "bread."

The Encoding and Retrieval of Declarative Knowledge

I will now turn to the two processes that are equally interesting to cognitive psychologists but perhaps slightly more relevant to educators: How is declarative knowledge encoded into these mental representations known as networks? And similarly, how is it retrieved?

A fundamental assumption of the network conception is that retrieval of declarative knowledge involves activating the appropriate nodes (Anderson & Bower, 1973; Anderson, 1976; Collins & Loftus, 1975). Thus upon reading the letters BREAD, hearing the phonetic sequence /bred/, seeing a picture of what we culturally ascribe "bread" to look like, or even thinking about the components of a sandwich, the mental representation for the concept bread -- its node -- is activated. Upon first learning about the theoretical idea of activation I immediately thought it sounded similar to illuminating ornamental lights on a Christmas tree (though I must admit to never having seen this comparison drawn in any cognitive psychology textbook). So, according to my

over-simplified analogy, a node becoming activated in a mental network could be likened to a light being illuminated on a Christmas tree.

A node must be activated in order for its contents to be available for ongoing processes. Once activated, the information represented by a node is usually available to consciousness; for example, one might have the conscious knowledge that the letter string BREAD is a word and even further, what that word means. In addition, once a node is activated, it is possible for this activation to "spread" down the pathways of the network. Continuing my analogy, spreading activation could be likened to illuminating one light on a Christmas tree and having that energy spread through the cables to some adjoining lights. Spreading activation serves to "prime" related nodes, so that they are in a ready state and soon may also become activated (Posner & Snyder, 1975).

Given the notions of networks, nodes, and activation, what is the best way to encode information so that it will later be accessible? The person on the street, perhaps many educators, and for several years the bulk of cognitive psychologists believed the same thing: to really learn something you must repeat it over and over again. Thus, there was unanimous agreement about the key to permanent encoding though laypeople called it rote repetition, educators referred to it as drill and practice, and cognitive psychologists dubbed it rehearsal.

The notion that repeatedly rehearsing information ensures its retention was perhaps a fallout from the behaviorists' principles of learning; it sounds similar to increasing habit strength. Surely, everyone's intuition predicts that rehearsal is the opitmal way to encode something, particularly when this something is a seven-digit telephone number that we have just received from a directory assistance operator. If we don't want to recode it in the external world (write it down), we simply continue to subvocalize it for a few seconds until we have completed dialing it. But there is the hitch. Usually when we use rehearsal to succesfully retain a phone number it is for a limited period of time and with the constraint that we not be interrupted. What happens when we rehearse the number long enough to dial it but find to our dismay that the line is either busy or there is no answer? Usually, if we haven't recoded it externally or processed it to a deeper level, which I will explain shortly, we find ourselves looking the number up again twenty minutes later when we want to replace our call. Similarly, many a directory assistance operator or telephone book has been reconsulted when our rehearsal is interrupted by something as innocuous as a spouse asking the location of a T.V. guide.

An elegant experiment by Craik and Watkins (1973) empirically tested the assumed relation betwen the amount of rehearsal and the probability of retention. In that experiment, subjects were presented with a series of word lists and each list varied in length. The subjects' task was to report the last word in a list that began with a specified letter. So, for example, the specified initial letter might be "g" and the list might begin like this: "daughter, oil, rifle, garden ..." Because

"garden," begins with the specified letter it is the word to remember. And the list might continue: "table, football, anchor, house ..." All the while, subjects are mentally rehearsing "garden." And the list might continue: "baby, grain ..." Now "garden" is no longer the last word in the list that begins with the specified letter, but "grain" is. So the subjects begin rehearsing "grain." And the list might continue: "candy, garage, mountain, camera..." This time the previous target word "grain" was quickly replaced by "garage." And the list might continue or it might end there.

The strategy here was that subjects, never knowing when the word list might end, would continue to rehearse the most recently presented target word unless another target appeared. Craik and Watkins (1975) had purposely varied the number of words that intervened between potential target words so that they could manipulate how long each target word was rehearsed. At the conclusion of all the lists, subjects were unexpectedly required to recall as many of the target words as they could. If the probability of retaining a word was a function of how long it had been rehearsed then those words which were followed by several non-target words should have been recalled more often than those followed by few. However, this was not the case. That is, the number of intervening words, hence, the amount of time that a word was rehearsed, did not affect the probability that a word was subsequently retrievable.

Well, if rote repetition -- or even its catchier title, rehearsal -- is not the key to better encoding, what is? Another experiment by Craik and (this time) Tulving (1975) provided a critical insight into what is currently believed to be the answer. In Craik and Tulving's experiment, subjects were again presented with a sequence of words, but unlike the study I mentioned before, the subjects' task was not explicitly remembering the words. Rather they were required to perform several different encoding tasks. All the encoding tasks entailed answering a question about one of the presented words. For example, the question might be: "Is the word typed in capital letters?" Or "Does the word rhyme with WEIGHT?" Or "Is the word a type of fish?" Or "Would the word fit in the sentence: 'He met a _____ in the street?'"

These questions were selected so that they varied in the depth to which subjects would have to process the word in order to come up with an answer. Deciding whether the word was typed in capitals presumably involves only shallow processing; one needs to encode only a few characteristic features of the typeface (e.g., presence or absence of descenders) in order to make this judgment. Deciding whether the word rhymed with another word also involves relatively shallow processing, though presumably a bit deeper than that required by the typeface judgment. This is because the words had been visually presented; so to make a rhyming judgment, subjects have to retrieve a mental representation of the phonetic (sound) structure of both the target word and the word they are to compare it to. Deciding whether the concept represented by the word was a member of a specified semantic category presumably involves deeper processing than the typeface or rhyming judgments; it requires retrieving at

least a couple of other members of the category and comparing them to the target word. Finally, deciding whether the word could fit in a specified sentence presumably involves the deepest processing of the four encoding tasks; it requires retrieving the meaning of all the words in the sentence frame as well as the target word's meaning (or potential meanings, if the word was slightly ambiguous -- e.g., ring). It then requires inserting the target word into the frame and mentally computing the meaning of the overall sentence.

Craik and Tulving (1975) had predicted that there should be a relation between the depth to which subjects were required to process the words and subjects' subsequent ability to retrieve them. The data nicely confirmed that prediction. When subjects later recalled as many of the words as possible, words to which they had made typeface judgments were remembered the worse; words to which they had made rhyming judgments were remembered only slightly better; words to which they had made category judgments were remembered even better; and words for which they had made sentence frame judgments were remembered the best of all.

The same relation has been demonstrated with materials larger than a word. For example, Schallert (1976) presented subjects with paragraph-long texts which she purposely constructed to be ambiguous. That is, two potential meanings or themes were available for each. For example, one passage could be intrepreted as revolving around either the Worries of a Baseball Team Manager or the Worries of a Glass Factory Manager. This passage included sentences such as: "'All we need now,' said the manager in one of his discouraged moods, 'is a strike.' I listened to him silently, but I could not help him. I hit a fly. 'I suppose things could get even worse,' he continued. 'Our most valuable pitchers might crack in this heat. If only we had more fans, we would all feel better." The subjects in Schallert's study performed one of three different encoding tasks: they counted the number of four-letter words; they counted the number of personal pronouns, or they rated the passages' ambiguity. These three tasks were assumed to vary from a very shallow level of processing (counting the four-letter words) to a slighly deeper level of processing (counting the personal pronouns) to a relatively deep level of processing (rating the ambiguity). Indeed, performance on both a recall and a recognition task, which is similar to a standard multiple-choice test, demonstrated that the deeper the level of processing, the better the retention.

In addition, a relation between depth of processing and retention has been demonstrated with non-verbal materials, for example, faces. Bower and Karlin (1974) presented subjects with photographs similar to those that appear in high school or college yearbooks. Subjects were required to judge either the gender of the person photographed (a relatively shallow encoding task) or the person's perceived likeableness or honesty (relatively deeper encoding tasks). And again this study, as well as countless others using both verbal and non-verbal materials, demonstrated that the deeper the level of processing, the better the retention (see Cermak & Craik, 1979, for a review).

Before going on, I should deal with some reasonable objections the reader might be developing at this point. Admittedly, none of the encoding tasks I have just described would be strategies a learner would employ in the classroom. Very few teachers would be pleased if their students' interpretation of learning a textbook chapter was counting the number of es on each page. So, one question the reader might be asking is: How does the most typical encoding task -- "learn the materials" -- stack up against the tasks I have described? A related objection concerns the issue of motivation. In the experiments I described, subjects presumably performed the encoding tasks without being informed of a subsequent test. (Well, at least to the extent that any subject who enters a psychological laboratory and is presented with a list of words does not suspect that he or she will later be held accountable for them.) So a related question might be: How does the most logical encoding task -- "learn the materials because you will later be tested on them"-- stack up? In cognitive psychology nomenclature, the sentiment expressed in this last strategy is referred to as intentional learning; it contrasts with incidental learning.

Perhaps most surprising to an audience of educators is the following tried and true finding: Whether one intends to learn the material or not is inconsequential (see Postman, 1964, for a review). Moreover, the relation between the depth to which incoming information is processed and its retention is independent of intent to learn. In fact, in many studies like the ones I have mentioned, there were control conditions in which subjects were simply told to learn the materials as well as possible. In other studies, there were comparison conditions in which subjects performed the same encoding tasks with versus without being informed that a subsequent test would occur. However, performance in these intentional conditions has never exceeded performance in the deepest level, incidental conditions (see Nelson, 1976, for review). Thus, the key to better encoding appears to be the depth of processing regardless of the intention or motivation.

Depth of processing is only a description of how knowledge gets better encoded; it is not an explanation of why. The theoretical explanation of depth of processing is that it engenders richer, more elaborate, mental representations (Anderson & Reder, 1979; Bransford, Franks, Morris, & Stein, 1979; Jacoby & Craik, 1979). This is best exemplified by describing one last depth of processing experiment. Bobrow and Bower (1969) presented subjects with pairs of nouns, one of which could be the subject of a simple sentence (boy) while the other could be its object (ball). For half the subjects, each pair of nouns was presented already embedded in such a sentence (The boy hit the ball). For the other half, only the noun pairs were presented and it was the subjects' task to generate their own sentence connecting the two. When later prompted with the first noun (the subject) and asked to recall the second noun (the object), subjects who had generated their own sentences were twice as successful as those who had received the experimenter created ones. In depth of processing terminology, generating a

sentence presumably involves a deeper level of processing. Moreover, to generate a plausible sentence, one must think carefully about the aspects of the two nouns that are related and consider candidate verbs that express those relations (threw, kicked, caught, batted, or bounced, ran with, ran toward, ran for, etc.) Though subjects eventually decided on just one verb, it is possible that during the process of arriving at that decision some of the related aspects of the two nouns and perhaps some of the candidate verbs were also encoded. If so, then the process of generating a sentence would lead to a richer representation than would encoding the nouns with only one predetermined verb. And this is why depth of processing is believed to enable better encoding; it promotes a more elaborate mental representation.

Consider again the representation scheme involving networks, nodes, and activation. According to this conception, elaborating on incoming material would create alternative pathways among the nodes in a networks. For example, a hypothetical memory representation of the experimenter supplied sentence is depicted in Figure 2. In contrast, Figure 3 depicts a hypothetical representation resulting from the subject generating his or her own sentence. In Figure 3, the primary connection between the two experimental nouns, "boy" and "ball," would be the pathways through the verb "threw," assuming it is the verb the subject finally decided on. However, additional, albeit less potent, pathways might exist between any of the other candidate verbs the subject considered as well as some of the related aspects of the two nouns the subject thought about. Thus, the network representation depicted in Figure 3 is much richer than the one depicted in Figure 2.

Figure 2. A hypothetical memory representation gained from encoding an experimenter supplied sentence.

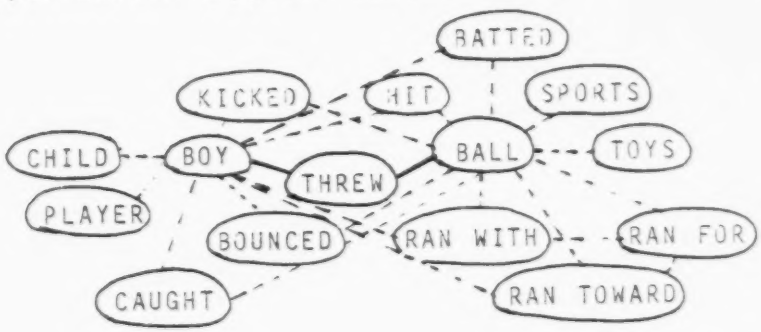

Figure 3. A hypothetical memory representation gained from creating an original sentence joining the two nouns.

When the notion of activation is considered, the contrast assumed between the two hypothetical representations becomes sharper and the advantage of the more elaborate one becomes clearer. When prompted with the word "boy," the pathways connecting it to any other node become activated. Because in the more elaborate representation, more pathways are connected to that concept, more pathways will be activated. Moreover, the activation from these pathways should spread thereby priming the concept "ball" both directly and indirectly. Ergo, subjects with the more elaborate representation should have a higher probability of retrieving the second noun. In addition, what if the direct connection between the two nouns via the pathway "threw" becomes inoperative for some reason? Presumably if any of the additional nodes are activated, the subject might be able to infer what the second noun really was. That is, the subject might remember that the sentence had something to do with a boy and something he could hit, kick, bounce, catch, or run with. Ah, it must be a ball. Thus, the richer mental representations promoted by elaboration facilitate retrieval by providing additional retrieval paths, indirect activation, and potential bases for inference.

Many activities induce richer mental representations. For example, generating a logical continuation for a phrase, sentence, or brief passage leads to a richer mental representation (Mistler-Lachman, 1972; Masson & Sala, 1978). So too does answering questions during ongoing comprehension (R.C. Anderson & Biddle, 1975, Frase, 1975). And one of the most potent routes to a richer representation is the use of visual imagery, i.e., creating a mental picture of the information (see Bower, 1970, 1972, and Paivio, 1969, for reviews). Indeed, forming elaborate and interconnected representations is in essence what Lorayne and Lucas (1974) suggest in their popular paperback of mnemonic techniques.

Implications for Computer-Based Instruction

The direct implication for instruction, computer-based or otherwise, is: To benefit encoding, provide learning situations that require elaboration. As I see it, computers are ideal for creating such situations because of two of their design features. First, a definitive characteristic of the new breed of micro- and mini-computers, (the ones most likely to be implemented in the classroom) is that they are interactive: The computer acts and the person reacts or the person acts and the computer reacts. Because of this characteristic, computers are particularly well equipped for allowing learners the opportunity to individually operate on the material presented to them. For example, while learning textual material the range of encoding tasks can range from having the learner answer simple yes/no questions to requiring him or her to write a continuation of an ongoing story (Rubin, 1983). Moreover, what is unique about operating on information via computer interaction is the fact that how the individual responds makes a difference. Surely a static textbook cannot provide such individually tailored interaction, and one

individual teacher can divide his or her attention in only so many directions. Thus, the range of individual response opportunities and contingencies provided by interactive computers can enable encoding situations considerably more elaborative than even those used in the depth-of-processing studies I reviewed earlier.

Second, one of the most desirable design features of computers is that they can present material in secondary or alternate formats. In particular, I am referring to computers' ability to display graphics, though their auditory (speech or tones) capabilities should not be overlooked. As I have mentioned, encoding information in an auxiliary format enables learning because it provides redundant retrieval paths.

Fortunately, both of these features are not only conducive to instructional gains; they are also two of the most attractive components of computer-based video games. Though very little systematic research has been aimed at finding out why video games are so attractive (Loftus & Loftus, 1983), Malone's doctoral dissertation (cited in Malone, 1981) is a welcome oasis in this barren, untrodded domain. Malone's dissertation comprised three studies. In the first one, he interviewed a sample of 65 grade school students, all video game aficionados, about their video game preferences. Based on these data, he conducted two experimental studies. In both the latter two experiments, he constructed several versions of a game, each version differing by one or two critical features.

In the first of these two experiments, Malone created various versions of the game Breakout. For those of you who have never played Breakout, let me describe its standard version. At the outset, eight vertical columns of bricks are displayed. Each column is one brick wide and about a dozen bricks long. The goal is to knock out all the bricks by bouncing a ball off a movable paddle. The paddle is fixed in its horizontal plane (against the left side of the screen) but the player controls its vertical orientation. The ball is initially set in motion and stays in motion by ricocheting off the bricks. Each time the ball bounces off a brick, the brick disappears and points are added to the player's score. If the player fails to make contact with the paddle and the ball, then that ball is lost. A player is allowed five balls to break out the entire set of bricks. Contrary to my dry description of this game, in Malone's interview study he found it to be the third most popular game of a set of 25.

Malone manipulated three different features of Breakout: whether or not (1) the computer displayed the player's score, (2) the ball ricocheted off the bricks, and (3) the bricks disappeared after they were hit. By combining the presence or absence of each feature with that of another he created six different versions of the game. Version 1 was identical to the orginal game I described above; in Version 2, the bricks did not disappear after being hit but the other two features were present; in Version 3, the ball did not ricochet but the other two features were present; in Version 4, the score was not displayed but the other two features were present; in Version 5, the bricks did not disappear after being hit and the score was

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not displayed though the ball ricocheted; finally, in Version 6, the score was not displayed and the ball did not ricochet though the bricks disappeared after being hit.

Each of Malone's subjects played each of the six versions for a limited period of time. After playing them all, subjects rated how well they liked each. Malone found that the most important feature contributing to the subjects' preferences was that the bricks disappeared after being hit. Thus, the primary component underlying at least this video game's attraction was that players could demonstrably operate on the situation. By the way, the least important feature was the score being shown, which perhaps runs counter to many people's intuitions about video game popularity.

In his second experimental study, Malone manipulated the features of a more educationally oriented video game. The game was Darts and it is intended to teach grade school students declarative information about fractions. The standard version of Darts goes like this: A number line appears on the screen with three balloons placed at random points along it. The player's goal is to try to guess the positions of each of the balloons by typing in a mixed number. If the player's guess is correct, an arrow appears and pops the balloon. If wrong, the arrow remains in the incorrect position and the player guesses again. The goal, of course, is to pop the three balloons by discerning their correct position. The number line is always one integer long; thus the correct positions always differ by their fractional value.

Malone created eight different versions of Darts by manipulating several of its features. His grade school-age subjects each played only one version for two 20 minute sessions. During this time, each subject could play the version of Darts assigned to him or her, or play a constant version of computerized Hangman, or switch back and forth between the two games. Malone measured how long each subject played his or her Darts version, as well as asked the subjects to rate how much they liked playing Darts (an absolute judgment) and if they preferred Darts to Hangman (a relative judgment). To make a long story short, Malone found that two of the most important components underlying the attraction of this video game were those I outlined above. That is, his subjects' preferences, regardless of the way they were measured, were for features that allowed operating demonstrably on the information (e.g., arrows appearing at the guessed positions of the number line) and features that presented the information in a secondary format via visual graphics (e.g., balloons in lieu of ordinary intersecting bars).

Processes Involved in Manipulating Procedural Knowledge

Now I will turn to a discussion of procedural knowledge. Procedural knowledge is just as its name implies, knowledge about how to proceed while doing something. The idiomatic content of procedural knowledge can run the gamut: from knowing how to twirl an "r" in Spanish pronunciation to knowing how to twirl a baton

on a football field; from knowing how to add two numbers together to knowing how to solder two pipes together; or from knowing how to set up a computer program loop to knowing how to set up a volleyball spike. The contrast I have purposely drawn with these examples is commonly considered a difference between mental versus motor skills. However, this difference is rather superficial because carrying out all these skills requires the same basic cognitive manipulations (encoding a mental representation of the process, storing that representation, and subsequently retrieving it). In the case of what are commonly considered motor skills, the mental representation simply involves the additional knowledge about how the appropriate musculature is enacted.

The sharper contrast I want to emphasize here is the one I drew earlier: the difference between procedural versus declarative knowledge. Let me illustrate this difference by referring to an example suggested by one of my colleagues in the Psychology Department at Oregon, Michael Posner (1973). Consider the knowledge possesed by a skilled typist. If a skilled typist is seated at a keyboard and asked to type the alphabet (in order, of course), the assignment is accomplished relatively effortlessly and usually within only a few seconds. To do this, the skilled typist retrieves procedural knowledge, knowledge of the processes involved in typing. Now if the same skilled typist is seated at a desk, given a blank diagram of the keyboard, and asked to fill in the letters in their appropriate locations, the assignment would be very different. What we first notice is that it takes even a skilled typist a considerable amount of time to do this and even then he or she is likely to make a few errors. To do this second task, the skilled typist must retreive declarative knowledge, knowledge about what the keys are labelled. And the process of retrieving this kind of knowledge appears to be qualitatively different from retrieving procedural knowledge. What we might also observe is that to fill in some of the letters the typist subtly moves his or her fingers much like subvocalizing during reading. Or the typist might just report that he or she had to mentally go through the motions of striking those keys. Thus, it appears that the typist is trying to recover declarative knowledge from his or her reportoire of procedural knowledge. In many cases, procedural knowledge is so well encoded in its own representation system that it is hard to recode it into declarative knowledge.

Let me illustrate this principle by relaying a personal anecdote. When I first moved to Oregon I was amazed at the number of people who used bicycling as a major mode of transportation, not just as a recreational pasttime as people had in Texas where I moved from. Considering the nice facilities Eugene provides for bicyclers, I decided that I too would do something small f the ecology and my physical fitness and start biking to work. However, I had neither owned nor ridden a bike since I was ten, so my first task was to purchase one. Friends advised me to buy one with ten speeds, though the one I had owned as a child was merely a single-speed (really, a no-speed). While driving in our car to the bike store, I asked my husband how one changes gears

on a ten-speed bike. He verbalized the procedures as best he could. In the back of my mind, I thought the situation sounded somewhat analogous to shifting the gears on a standard transmission car. But I did not know if analogous to taking one's foot off the gas when depressing the clutch, one should stop pedaling when changing a bike gear. I asked my husband and he quickly answered that I should. Well, after riding my new bicycle for several days I was still unable to shift gears smoothly. I even asked a couple of other people to describe the process and when they failed to mention whether I should stop pedaling, I queried them directly. One said I should and the other said I should not. I figured it was a matter of personal preference and went with the majority's preference. But when I still was having troubles shifting gears smoothly I decided to observe what my husband did while actually in the process. Lo' and behold, he continued to pedal. Thus, for my husband and half the additional people I surveyed, shifting gears on a bicycle had become such a proficient skill that they had difficulty translating procedural knowledge into declarative knowledge.

Because procedural knowledge appears to differ so much from declarative, it is proposed that the processes underlying its manipulation are also different. In decribing these processes, I will again rely on the categorization I used when describing what is known about manipulating declarative knowledge, namely encoding, representation, and retrieval, and I will talk about them in that order.

Encoding Procedural Knowledge

Procedural knowledge is most often manifested in skills. For this reason, it is useful to talk about encoding procedural knowledge in terms of acquiring a skill. Fifteen years ago, Fitts and Posner (1967) decomposed skill acquisition into three stages; such a framework is still very useful today. Below I will describe these stages, though I have modified them slightly.

The initial stage can be considered a conscious stage. During this stage, the learner acquires declarative information about how to perform the skill. For example, a beginning Pascal programmer learning to write his or her first program might be instructed: "The first word of every Pascal program is the reserved word PROGRAM" (Cooper & Clancey, 1982, p. 4). A more advanced Pascal programmer learning to make actions continue conditionally (i.e., write a loop) might be instructed: "The action of a REPEAT structure will take place at least once; the WHILE loop's action may not be executed at all. The REPEAT structure's exit condition, when met, causes looping to stop. The WHILE's entry condition, when met, causes looping to continue" (Cooper & Clancy, 1982, p. 187). Thus, during the conscious stage the learner is basically acquiring a set of rules or descriptions about how the skill is performed.

The knowledge encoded during the conscious stage is, however, relatively inadequate for performing the skill well. This is attributable to two related factors. First, one obvious problem is that the learner is not encoding procedural knowledge

but rather declarative knowledge. And, as I will discuss below, procedural knowledge is represented in a different mental "format" than declarative knowledge. Presumably, to accomplish the skill proficiently one must retrieve procedural, not declarative, knowledge. The second reason why the knowledge encoded during the conscious stage does not enable immediate proficiency is the issue I commented on earlier via my bicycle anecdote. When procedural knowledge is well encoded it is often hard to recode it into declarative knowledge. Now consider who or what is imparting this beginning instruction to the novice. Usually, it is an instructor already proficient in the skill or a textbook authored by someone who is also already proficient in the skill. Hence, the difficulty encountered during the conscious stage of skill acquisition boils down to a bi-directional problem in translation: going either from declarative knowledge to procedural (translating rules into behavior) or vice-versa (translating behavior into rules). This latter factor probably explains why so many of the manuals that accompany software or hardware seem utterly incomprehensible to the new user.

The second stage of skill acquisition can be considered an attentional stage. During this stage, the learner begins to acquire more procedural knowledge but it is with attentional effort. So for example, the beginning Pascal programmer no longer receives an error message that the reserved word PROGRAM is missing from his or her program. However, he or she might have to momentarily pause at the outset of writing each program to remember that it must begin with this word. Similarly, during the attentional stage, the more advanced Pascal programmer no longer writes programs in which an intended loop's entry condition never occurs, or conversely, the loop continues indefinitely. However, phrasing the loop's code requires thinking through the logic of its expected role.

During the attentional stage procedural knowledge does not necessarily replace declarative knowledge (Anderson, 1980). Rather, it is possible that the two coexist; in other words, they are both mentally represented. For example, though most of us posess procedural knowledge about how to speak English fluently, we no doubt still have access to some of the grammatical rules we encoded at an early age in declarative form (compound subjects take plural verbs).

The third stage of skill acquisition can be considered an automatic stage. During this stage, executing the skill appears relatively effortless. The beginning Pascal programmer no longer pauses momentarily to remember to include the word PROGRAM, he or she just writes it. Similarly, in little more time than it takes the advanced programmer to type the characters, he or she has written a bug-free loop. The automatic stage is characterized by a lack of conscious awareness. For example, as fluent English speakers we are no longer consciously aware of the pronunciation, grammatical structure, or wording of every utterance we plan and produce. Rather, in most situations, we execute the skill quite automatically and apparently effortlessly. In fact, in most situations we can carry on a conversation while performing another skill, such as driving a car or preparing a meal. This

illustrates another characteristic of the automatic stage; it is the point during skill acquisition where fewer mental resources are required to perform the skill at a constant level of proficiency. For this reason, immediate attention can be committed to other ongoing processes.

The Representation and Retrieval of Procedural Knowledge

Like declarative knowledge, procedural knowledge is believed to be represented in an organized fashion. And again the notion of networks has been forwarded as a suitable representational structure. However, unlike declarative knowledge, procedural knowledge is not stored within conceptual nodes. Rather it is stored in nodes containing mental representations of productions (Anderson, 1976; Newell & Simon, 1972; Newell, 1973). A production comprises two parts: a condition and an action. For example, a verbal translation of a production for beginning a Pascal program might be: If the goal is to write the initial line of code, Then write the word PROGRAM. Note that the production contains two clauses; one leads with "If" and the other with "Then." The If clause or statement is considered the production's condition and the Then clause is its action. Presumably the two clauses work together; when the condition is met (the immediate goal is to write the initial word of code), the action is implemented (the programmer writes the word PROGRAM).

Moroever, when the production's condition is met, the production is activated. And again as with declarative knowledge, activation can spread down the pathways connecting the production nodes. So activation of the production I verbalized above might lead to activation of a related production, for example: If the word PROGRAM has just been written, Then identify the intended INPUT and OUTPUT. One explanation for why skill acquisition involves the development of greater automaticity is that as proficiency increases the productions become more comprehensive. That is, information that used to be stored as single productions merges into one larger production. For example, as the Pascal programmer becomes more proficient, he or she may now have the replaced the two productions that I gave as examples earlier with a more comprehensive one: If the goal is to begin a program, Then write the word PROGRAM and identify the intended INPUT and OUTPUT. Thus, increased skill proficiency is accompanied by more efficient production manipulation. And this efficiency is made possible via hierarchical consolidation (Dickelgren, 1976) or chunking (Chase & Simon, 1973).

The production framework has been used successfully to describe the processes involved in manipulating many classroom skills, for example, solving organic chemistry (Larkin, 1983), algebra (Clement, Lochhead, & Soloway, 1979, cited in Larkin, 1983), physics (Larkin, McDermott, Simon, & Simon, 1980), and geometry (Lewis, 1981) problems. The topic of the next section will be this framework's implications for acquiring the procedural knowledge involved in programming skill.

Implications for Computer Programming Instruction

My discussion here will center around four principles of skill acquisition and their suggested applications. The majority of these suggestions were originally presented by Anderson (1980) and are simply being summarized here. The first principle concerns the spacing of practice. When acquiring a skill, practice sessions can be either spaced over time or massed together. Other things being equal, spaced practice is superior to massed. Indeed, one of the ways in which acquiring procedural knowledge has been shown to differ from acquiring declarative knowledge is that spaced practice is considerably more facilitative when learning how to do something than learning what something is (Drowatzky, 1975). Gay (1973) has empirically demonstrated the benefits of spaced practice during the acquisition of algebra skill.

However, as Anderson (1980) points out, there is a finer level on which to interpret this suggestion. Spaced practice could refer to practicing programming skill interwoven with practicing a skill from another domain or to practicing one aspect of programming skill interwoven with practicing other aspects. The suggestion is intended to be interpreted as the latter activity. For instance, when learning how to construct a loop, it is preferable to continue practicing loop construction throughout the remainder of the programming course than to concentrate on it during just one phase of the course. This suggestion also has direct implications for textbooks. Their usual format is to present a topic, follow it with several exercises, and then move on to a new topic. This is not the optimal strategy. The instructor should keep this principle in mind when selecting a textbook, and either select one with an optimal format, or modify the syllabus so that a topic is not dropped once it has been reasonably mastered.

The second principle is directly related to the first. It concerns hierarchically automating sub-skills. Nearly all skills can be decomposed into their component sub-skills. Further, these component sub-skills are related to one another in either a horizontal or a hierarchical way. For instance, in Pascal, learning to construct IF statements is horizontally related to learning to construct WHILE statements just as the class of dogs is horizontally related to the class of cats. In contrast, learning to construct IF statements is hierarchically related to learning to construct CASE statements just as the class of dogs is hierarchically related to the class of animals. The suggestion here is that sub-skills should be acquired in as close to a hierarchical fashion as possible. The reason is that once a subskill is mastered, it becomes automatic, and it requires less attention. Because executing that sub-skill now requires less attentional capacity the logical place to turn is toward acquiring another sub-skill that encompasses the already acquired sub-skill, in other words, a new sub-skill that is higher in the hierarchy. In this way, more capacity is available for learning that next sub-skill (the higher level one), than if a sub-skill was approached that was only horizontally related. Moreover, learning sub-skills in a hierarchical fashion ensures that

previously acquired sub-skills will continue to be practiced.

The third principle concerns the effects of knowledge of results. Humans almost always learn a skill faster if they receive constructive feedback (Keele, 1973). Note, however that constructive feedback is not synonymous with reinforcement (a reward ranging from a verbal compliment to a handful of M&M candies). Constructive feedback is simply an indication as to whether a recently executed attempt is correct. If incorrect, an equally important facet of constructive feedback is an indication as to how the attempt is in error. Many programming languages are yoked with "smart" compilers that give relatively informative error messages. However, some compilers are not so nice; their repertoires of error messages are too few to catalog. Other things being equal, preference should be given to teaching programming languages that supply the most informative error messages and hence the most constructive feedback (see Green, 1983, for a review of programming languages vis a vis classroom suitability). In addition, constructive feedback is most beneficial when it quickly follows the attempt. Perhaps even the first year teacher is aware of this principle. But a less widely known principle is that the shorter the delay between knowledge of being correct and a second attempt, the better. While acquiring programming skill, this principle is usually not implemented. The more common agenda is that learners feel very task bound; once they write a successful program or subroutine, they feel the task is finished. But it is primarily at this point that they should be required to successfully repeat the attempt.

The fourth principle concerns internalizing an ideal model, a good model of what the skill should be like. Recall the basic problem in translating procedural knowledge to declarative that I spoke about earlier. In many cases, the more beneficial route to learning how to do something is to observe someone doing it proficiently. What the learner observes can then form the basis of his or her mental representation; that is, the learner can internalize the ideal model. So, the implication here is that it is important for the novice programmer to have access to at least one, if not several, ideal model(s). I can personally attest to the benefit of applying this principle. My laboratory is now controlled by an Apple computer. For several reasons, when I first began setting up my lab, no one was available to help me program the Apple, or even better, simply do it for me. So I decided to take the bull by the horn, and become acquainted with computers beyond the level of their word processing capabilities. At first, I relied only an instructional manual, which -- in most flattering terms -- was pretty bad. For financial reasons (or perhaps the Oregon re-cycling mentality), I recruited some used diskettes from other members of the department. Before writing over the diskettes, I glanced at some of their contents. One contained several programs written by our departmental programmer. By observing the ideal model portrayed by these programs I learned quite a bit more than I had during several hours of memorizing the manual. In addition, I continued to consult these ideal models as my level of skill progressed.

To summarize, the four principles I have discussed here are:

Spaced practice is more conducive than massed; sub-skills should be automated in a hierarchical fashion; knowledge of results (feedback about accuracy and source of error) facilitates learning; and the novice should internalize an ideal model of how the skill should be executed. Anyone who has gained proficiency in playing a video game can immediately see how these principles were manifested in that pursuit. During acquisition of this skill, practice is spaced over time by default. Because playing the games is recreational rather than vocational, only a limited period of free time is available for any one session. Moreover, because the arcade versions require capital, only a limited amount of spare money is available. Even with the home-based versions, there is a constraint that forces the player into spaced sessions: How long can the rest of the family sacrifice the household's color television to PacMan in lieu of "Hill Street Blues?" Thus, video game skill proficiency usually develops via frequent though limited practice sessions.

The principle of sub-skill automation is also demonstrated in learning how to play a video game. Virtually all video games are constructed around a hierarchy of goals. For example, in describing the video game Sabotage, Loftus and Loftus (1983) present the game's objective(s) in a tree-like graph. The seventeen subgoals range from learn to "identify which paratroopers are falling directly above paratroopers already on ground" and "compensate for fast oblique motion" to "keep paratroopers from accumulating on ground" and "keep from being bombed." Horizontally related subgoals are: "learn to hit helicopters," "learn to hit parachutes," and "learn to hit paratroopers." Indeed, Malone (1981) found in his interview study that the more overt the goal hierarchy, the stronger the video-game's attraction.

Mechanisms for providing knowledge of results are also inherent to video games. Without exception, when an attempt is correct, a noticeable effect occurs: when Mario sucessfully reaches the top of the building, the woman captured by Donkey Kong is set free; or when Pac Man sucessfully gobbles up a coveted energizer, his monster pursuers are transformed momentarily into pursuees. What is lacking from video games, however, is constructive feedback about how attempts are in error. Perhaps this is why many potential aficionados lose their quest for proficiency at an early stage of skill acquisition; they simply become frustrated not knowing how they can improve.

In response to this frustration, Ken Uston published his guide to Pac Man (1982). Although it is a compilation of declarative information, it comes the closest to providing a tangible ideal model for those eager to develop Pac Man proficiency I know of. As with other skills, less tangible and perhaps more beneficial ideal models can be obtained through observation. Indeed, a good proportion of those present at a video game arcade are doing just that: They are looking over the shoulder of a more accomplished player. What is interesting is that very few didactic words are interchanged; rather, what I assume is transpiring, is that the novice is trying to internalize an ideal model of the skill.

Conclusions

In this paper, I have tried to present what contemporary cognitive psychology and the current video game craze have to offer the educational system as it begins its ascent into the Computer Age. Summarizing twenty years of theoretical positions, empirical data, and some more recent real-world observations has not been easy. Surely, there are applicable principles that I have overlooked. Further, even the most conscientious application of the principles I elaborated on here will not make the arrival of today's computers in the classroom an automatic success. However, I will conclude on the same optimistic note I began with: Today's computers can fulfill the promisory notes offered by yesterday's technology if yoked with an understanding of the workings of the human mind.

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Acknowledgments

Preparation of this paper was made possible through funds received from the IBM Corporation to the Cognitive Science Program at the University of Oregon.

INFORMATION TECHNOLOGY AND EDUCATION:

PUBLIC POLICY AND AMERICA'S FUTURE

D. Linda Garcia
Fred W. Weingarten

It is a pleasure to be here today to speak to you. This talk is based, to a large extent, on the findings of our report, Informational Technology and the Impact on American Education, conducted by the Office of Technology Assessment and delivered to the Congress a little over a year ago. However, as much time has passed since then, I will also take into account subsequent events and analyses, including the recent release of an OTA report on manufacturing automation that examined impacts on education and training.

The Office of Technology Assessment (OTA) is an agency of Congress responsible for examining the long-term policy impacts of new technologies. Bipartisan and bicameral, it performs its studies in response to requests by one or more committees. It is overseen by a Technology Assessment Board consisting of six Senators and six Congressmen, three of each from both parties.

In 1980, the Office was asked by the House Committee on Science and Technology and the House Committee on Education and Labor to look at the potential impacts of new information technologies on education. The committee had observed, correctly, that a number of radical new technologies and services based on them were just about, or were on the verge of being, introduced in the marketplace. At the same time, the education system seemed to be undergoing significant stress. The committee wanted to know if the issue of technological aids to education, one that had remained dormant for some years, should be raised again.

The study took two years to complete (about typical for OTA reports) and spanned a time of great change in the debate. Whereas at the start, only a few people even

considered the question worth raising; by publication time, the issue was front page news, particularly with respect to the impact of microcomputers.

It is important to point out that the study was deliberately conceived to be broad in scope. Hence, although microcomputers are an important element of the report, it also looks at a wide range of computer and communication-based products and services, ranging from intelligent videodisks to satellite broadcasting. Similarly, although schools form an important part of the study, other educational environments, ranging from the home to the workplace, were also examined.

The report illuminated three basic findings:

- the growing use of information technology throughout society is creating major new demands for education and training in the United States and is increasing the potential economic and social penalty for not repsonding to those demands.
- Information technologies offer promising new tools, although no panaceas, to respond to these and other demands.
- the information revolution is creating new stresses on many societal institutions, particularly those such as public schools and libraries that traditionally have borne the major responsibility for providing education and other public information services.

Education in a High Technology, Information Society

An important link between our past and our future, education must continually adapt to social change. Henry Adams was sensitive to this problem when, eighty years ago, he pondered his own education, asking: "What could become of such a child of the seventeenth and eighteenth centries, when he should wake up and find himself required to play the game of the twentieth?"[1]

In the study on information technology, OTA sought to answer the question of whether or not children, educated today, will be appropriately equipped, with knowledge and wisdom, to operate effectively in the world of tomorrow. Given the rapid speed in which change is taking place, and society is all too meager ability to predict the future, this task of redefining educational needs and goals was, of course, a staggering one. But, with this qualification let us share with you some of our conclusions.

Many findings were based upon case studies that were conducted in a variety of education settings. OTA looked, for example, at the use of technology in schools, community colleges, universities, libraries, museums, businesses, trade unions, and the home. These case studies have turned out to be one of the most popular sections of the report, and they reproduced in full in the appendix.

Two conclusions followed from these case studies.

- Information technology holds significant promise as a mechanism for responding to the education and training needs of society, and that it will likely become a major vehicle for doing so in the next few decades,

and secondly that:

- Information technologies are already beginning to play an important role in providing education and training in a number of sectors.

While these findings may seem common place today, they certainly were not when the study began. While the study began by emphasizing the opportunities that information technologies provide for education the staff soon came to realize that they

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1. As quoted in "Education for a High Technology Future: The Debate Over the Best Curriculum." School Research Forum, Educational Research Service, May 1983, p. 2.

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had to look at how the development and deployment of the new technologies might affect the nature of the educational system itself.

Technology has always had an affect on eduation and on the kind of knowledge an individual needs to have to participate effectively in society. Any new technology can, for instance, increase the importance of some skills while reducing that of others. For example, the invention of the printing press and the development of processes for duplicating books provided, at the time of the Reformation, members of the middle classes with the information and channels of communication necessary to challenge the authority of the traditional literati.

On the other hand, information technologies can also increase the number and level of skills required to be literate, and the number of the classes of people who need to have them. Thus, while the provision of printed materials to the general public made mass literacy possible; in the long run, it also made it necessary. It created a world in which individuals were required to be able to read in order to fully participate. It created a world in which societies needed to have a literate citizenry in order to experience social cohesion, political community, and economic growth.

The last hundred years has witnessed a rush of new information technologies that have included the telegraph and telephone, broadcast communication, photocopier and facimile transmission, computer, and related software, considered to be an equally important technology in its own right. These inventions have increased the speed at which information can be collected, stored, manipulated, and transmitted; increased access to information; and enhanced our ability to use information to account for past actions and to predict future events.

In the next few decades, information technologies will continue to undergo rapid development, and they will be applied to an ever expanding number of activities and tasks. The development and widescale deployment of these new information technologies have helped to give rise to what some social observers have characterized as a post-industrial, or "information, society."[2] In this society, the creation, use, and communication of information will play a central role. Not only will there be more information there will also be a greater reliance placed upon it.

In the economy, information will serve as the primary economic resource, the most important factor of production. It will become, moreover, a prerequisite to the development and allocation of all other resources. Given its economic importance, information will be treated less and less as a free good, and more and more as commodity, to be bought and sold in the market place. As the economic value of information and knowledge increases, so too will the economic rewards for those who have the greatest access to it.

Information will also come to play a central role in the political process. It will increasingly be brought to bear to make decisions about the complex problems of an advanced industrial society. As the value of information to decision-making increases, information and ability to store, manage, retrieve, and manipulate it will become ever more important as a source of political power.

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2. For discussions and characterizations of the "information society," see, for example, Susan Artandi, "Man Information, and Society, New Patterns of Interaction," Journal of the American Society for Information Science, January 1979, Daniel Bell, The Coming of Post-Industrial Society, Basic Books, 1973, and Peter Drucker, Technology, Management and Society, Harper and Row, 1970.

An increase in basic literacy and in technological understanding will be essential to the well-being of an information society. Gains in productivity and economic growth will be limited if workers are unable to adopt new techniques, to fill new types of jobs created by innovation, or to conduct basic research and development in promising new fields.

The problems involved in trying to successfully predict and identify the educational curriculum and requirements that would be most suitable to meet the general manpower needs of a high technology society are indeed formidable. For the widespread application of electronic technologies throughout the economy will, in the long run, actually change the very nature of work.

Economists and sociologists disagree among themselves about how the widescale deployment of these new technologies will affect future levels of employment and the stratification and distribution of jobs. Some argue that the skill requirements for most jobs will increase; while others predict that they will decline. Using the projections of the Bureau of Labor Statistics, economists Henry Levin and Russell Rumberger, for example, contend that, even though the number of high technology jobs will increase by a rate of over 100 percent, their size, relative to the total number of low skilled jobs, and thus their proportion in the overall economy, will actually decrease.[3] Arguments such as these have led some observers to conclude that we are moving in the direction of becoming a bimodal society, in which the middle class, and middle class values, will cease to exist.[4]

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3. Levin, Henry M., and Russell W. Rumberger, The Educational Implications of High Technology, The National Institute of Education Report #83-AH, 1983.

(continued)

Noting that future skill requirements will be determined not only by the number of new jobs created, but also by how we apply new technologies to old jobs, Marc Tucker, the former Associate Director of the Program on Education Policy and Organization, at the National Institute on Education, has, on the contrary, argued that we should not -- in fact that we cannot accept these predictions as an accurate picture of the future. Rather we should view them as one possible scenario, a scenario that we indeed have the choice and the means to alter. If, according to Tucker, we want workers to maintain their standards of living in a highly competitive, high technology economy, then we will have to train them to add more value to their products. In his words,[5]

> Adding more value per worker has consequences for workers at every level of the workforce. Secretaries whose only skills are typing, filing, answering the phone and getting coffee will be unemployable. They will have to able to locate needed information at near and distant points, figure out what is relevant to the task at hand, acquire it, format it, analyze it, incorporate it into other documents and send it where it is needed. Builders will not succeed in business unless they can use sophisticated techniques to plan, cost, bid and manage projects without hiring high priced analysts to perform these functions. Tire dealers will fail unless they know how to create and use inexpensive data bases to match the customer's wheel to their

4. Bob Kuttner, "The Declining Middle," The Atlantic Monthly, July 1983.

5. Marc S. Tucker, "Computers in the Schools: The Federal Role," Position paper prepared for a meeting of the Special Interest Group on Computer use in Education of he Association for Computing Machinery, September 3, 1983.

tire inventory, and find the tire they need quickly. Big city lawyers will not be able to compete effectively with up to date country cousins if they do not have the means for quickly accessing all the court decisions that bear on the case, querying an expert system for advice on how to handle it, and generating their briefs with automated methods. And so on.

Even if the percentage of highly skilled positions in the economy does, in fact, decline, individuals will still need to have greater scientific knowledge and enhanced information skills to participate fully in the social, political, and cultural life of a high technology society. For no society can remain free and democratic if the public's skills and knowledge fail to keep pace with the growing complexity of the problems that it faces. Citizens of the future will have to make choices about such knotty issues as toxic wastes, genetic engineering and advanced weapons systems. Since many of these issues are without precedent, making decisions about them will require the development of new bases of information and new modes of thinking. Rapid changes have rendered the past less useful as a guide for many of the problems that we face today and the we will face in the future. If information is to be brought together to provide greater knowledge and understanding, then new conceptual frameworks will need to be developed. And, if in an age of information specialization, social problems are to benefit from the application of science, and if the application of science is to be subject to moral and political choice, then new bridges between educational disciplines will have to be constructed.

Increase literacy and information skills will also be essential to an individual in an information society. Information will become the primary means by which people gain access to income, status, and authority. To fully participate in the economic, political,

social and cultural life of such a society, it will not be enough to be able to read and write, or even to be able to receive and transmit information with the new technologies.

Individuals will have to know how to evaluate information and to manipulate it to make it relevant for their own particular needs. Above all, in a world of rapidly changing technologies, they will need to be able to think critically and to fashion new knowledge out of a continuously changing base of information.

People will have to deal with greater amounts and a greate variety of information. Moreover, they will be subject not only to the information they, taking advantage of the new information technologies and services, generate for themselves. They will also be increasingly subjected to efforts by others to use the same information resources in an attempt to influence their economic and political choices. As the amount of information people receive increases, they may have less time and fewer resources available to process and to evaluate it.

In an information age, therefore, people will have to continually update their knowledge. Lifelong education will become the norm, and much more of it will occur outside of the traditional education processes. As information rapidly changes, the emphasis in education will be on process -- on how we learn -- rather than on content -- on what we learn.

Now that we have identified some of the educational needs of an information age, let's return for a moment to Henry Adam's question, and ask how well we are preparing people to live in it. By all accounts -- and there certainly have been many of late -- the answer is that we are not doing particularly well. As your know, a number of major reports have been released recently that have raised serious questions about the poor

performance of American students and the generally low quality of American education -- A Nation At Risk, the report of the National Commission on Excellence, the report of the Twentieth Century Fund Task Force on Elementary and Secondary Education, and the report of the National Task Force for Economic Growth -- to name just a few.

Common to all these reports is the view that education in America today is, at best, mediocre. Concerned about whether or not the U.S. economy can compete effectively in an era of high technology and international competitiveness, much of the discussion has focused on the problems in the fields of math, science, and engineering education. Of equal, if not greater concern, however, is the fact that the nation's schools, bureaucratically designed as they are today to meet the needs of the industrial age, may find it extremely difficult to adapt their style and curriculum to meet the needs of a post-industrial, high technology society.

On the other hand -- and on a more positive note -- it is clear, given the numerous recommendations that have been put forward by the various task forces and commission evaluating American education, that the problems we face are not irreparable. To solve them, however, will require a much greater recognition of, as well as a renewed commitment to, the concept of education as public good.

The Stress of Competition in an Information Age

This leads, of course, to the second point that I promised to discuss -- our finding that the information revolution is creating new stresses on many societal institutions, and particularly on those public institutions that have traditionally born the major responsibility for providing education and other public information services.

For as the economic value of information has increased, what we have found is that there is a much greater tendency to treat education as a private rather than as a public good. Before I describe this trend, let me say a little bit about the way in which Americans have traditionally regarded education as a public good.

Individuals and governments have often differed with respect to how they have treated education, and as to how they believed educational decisions should be made. Plato and Aristotle believed that education was so important that it should be monopolized and controlled by the state. Rousseau, on the other hand, was opposed to all formal schooling, believing that nature was the best teacher.

In the United States, education has traditionally been treated as if it were a public good. Most educational decisions have been made in the political arena; and most educational activities have been supported, if not financed, with public funds. This practice of treating education as a public good reflects, in part, the traditional American belief that education plays an essential societal role. Contrasting the attitude of Americans toward education with that of the Europeans, Alexis de Tocqueville, the well-known 19th century commentator on American society, noted in 1831:[6]

> 'Everyone I have met up to now, to whatever rank of society they belong, has seemed incapable of imagining that one could doubt the value of education. They never fail to smile when told that this view is not universally accepted in Europe. They agree in thinking that the diffusion of knowledge, useful for all peoples, is absolutely necessary for a free people like their own, where there is no property qualification for voting or for standing for election. That seemed to be an idea taking root in every head.

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6. Alexis de Tocqueville, Journey to America, translated by George Lawrence, J.P. Mayer (ed.) Anchor Books, 1971.

The traditional American belief in the public virtues of education is nowhere better illustrated than in the historical commitment to a system of public schooling. This system is a unique and typically American institution. For, while educational institutions are publically supported in many societies, in no other country have they been established with such deliberate purpose and public expectation, or been conceived of as being such an integral part of the political, social, and economic order.

The public benefits that Americans have associated with education have changed over time and in different historical circumstances. In the earliest years of American history, education was, for example, considered to be essential for the survival of the new democratic nation. Later, with the need to acculturate immigrants into society and to unite a divided nation in the aftermath of the Civil War, it was considered the means for building a nation of citizens. At the turn of the century, education was expected to train and socialize American youths for participation in a modern, industrialized society. More recently, Americans have seen in education the solutions to some of the nation's thorniest social problems.

To guarantee that these public benefits would be provided, Americans established -- in addition to elementary and secondary schools -- a whole range of public educational institutions such as pre-school programs, museums, libraries, special institutes, and two and four year colleges. Moreover, to assure that private educational institutions served public goals, they supported and regulated them.

Americans were able to treat education as a public good because, having similar needs and agreeing essentially upon the rules by which lived they were able to agree upon the kind of education that they wanted to pass on from one generation to the next.

Given this consensus, there was little conflict between what was a public or a private educational interest, or between what was a local or a national education goal.

Even more important, throughout their history, most educational institutions have had very little competition in carrying out their many social, economic, and political tasks. Thus, they were, in effect, able to cross subsidize. For the public's economic and political support for the most popular functions that schools and universities performed was usually great enough to subsidize the less favored ones. Today this is no longer the case.

Taking advantage of the rising value of information and information related products, profit-making institutions are now beginning to take on some of the most lucrative tasks that American educational institutions have traditionally performed. It is not surprising nowadays, for example, to see Radio Shack selling courses in computer literacy. Because they are capable of providing specialized services to narrow segments of the educational market, the new information technologies may exacerbate this trend, making it easier to produce and distribute education in the market place.

As profit-making institutions take on more and more of the money-making educational functions, public institutions will have fewer resources -- social as well as financial -- to devote to non-economic educational objectives. Moreover, to survive, the traditional institutions will have to compete with the new, profit-making ones, and to successfully do so they will have to increasingly view their functions and weigh their decisions in economic terms alone.

The problems that educational institutions have confronted in competing with private institutions in the free market are clearly evident when we look at their efforts

to recruit faculty. In schools of engineering, for example, 15 to 20 percent of all faculty positions are unfilled, and the number of Ph.D's graduating each year has dropped significantly, from 3700 in 1972 to 2800 in 1982.[7] The faculty shortage is so great, in fact, that as many as twenty universities have had to limit their engineering enrollment.[8] Facts and figures such as these should not surprise us, however, when we consider that industry typically pays an inexperienced electrical engineer with a bachelor's degree slightly more than a university will pay an assistant professor of engineering with a Ph.D.

Just as universities cannot compete with industry in attracting scientific talent with inducements of high salaries, neither can they draw, them, as they have in the past, and as many industries now do today, with promises of high quality facilities and state of the art equipment. The high cost of much of today's high technology equipment is often prohibitive. Moreover, in an effort to reduce costs, many college administrations have failed to maintain or to upgrade the buildings and equipment that they already have. As a result of these decisions, university inventions are nearly twice as old as those of leading commercial labs.[9] The National Society of Professional Engineering estimates, for example, that the cost of providing adequate equipment to all engineering departments would be on the order of 1½ to 2 billion dollars.[10]

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7. Jeanne McDermoth, "Technical Education: The Quiet Crisis," High Technology, November/December, 1982 p. 87.

8. Jerrier A. Haddad, "Key Issues in U.S. Engineering Education NAF Bridge, Summer 1983, p. 11.

9. John Brademas, "Graduate Education: Signs of Trouble," Science, March 2, 1984, Vol. 223, P. 881.

(continued)

Failure to resolve these problems may seriously impair engineering education in the United States. In the last three years, for example, 30 percent fewer engineering schools were given full six year accredidation. Moreover, there has been an increase of over 70 percent in the number of institutions that have been asked to show cause as to why their accredidation should not be terminated.

Nor are such staffing problems unique to universities. At the elementary and secondary school levels, for example, the individuals who, in another era, might have taught math and science are now flocking to industry where starting salaries are double the amount offered within the public school system. Because there are so few math and science teachers available, many of those who are teaching math and science in our schools today are actually unqualified to teach in these subject areas.[11] It is not surprising, therefore, that American students find science the least appealing of all subjects and that, in international comparisons of science achievements scores, United States students did more poorly than did those of any other developed country.[12]

In order to deal with the kinds of problems that they face today, many public educational institutions have had to curtail the services that they provide, retaining only those that have the greatest economic and political returns. Others have begun to market their knowledge and information products. Thus, we find public libraries offering access to new electronic data base systems for a fee, and we see universities rushing to patent ideas that once were made freely available to a community of scholars. This

10. Op. cit., Haddad.

11. New Scientist, July 14, 1983.

12. Herbert J. Walberg, "Scientific Literacy and Economic Productivity in International Perspective, Daedalus, Spring, 1983, p. 12.

growing tendency to focus on the economic value of education has recently been noted and decried by secretary of education Terrel H. Bell. Speaking at a Joint Conference of the American Council on Education and the Association of Universities and Colleges of Canada, he condemned "pragmatic vocationalism and careerism" in higher education warning that some colleges are in danger of becoming little more than "glorified work preparation institutes."

We can also see evidence of this trend in the present national debate on education. Where the rationale for taking action is, for the most part, an economic one, where the emphasis is on those skill areas -- such as math, science, and engineering that will match our anticipated manpower needs. One should certainly not be opposed to learning math and science. On the contrary, but one must wonder if there are not equally valid reasons, apart from the economic ones, why all Americans should not, through the learning of science, come to understand and appreciate more fully the complex would in which they live. It might be better to have a system more like that of the ancient Greeks and Latins in which math and science were not considered to be specialized, vocational fields, but rather, like history and philosophy, they were considered to be part of the humanities.

If education comes to be regarded more and more as a commodity, or as a means to an economic end alone, fewer resources will be available to perform the other, less profitable, but none the less equally important, public functions of education. Such a trend would be quite disturbing considering that, given the enhanced role that knowledge will play in the future, the nature and goals of the educational system will determine not only the economic roles, but the very quality of our lives.

In 1984, George Orwell painted a rather dismal picture of a future society in which a narrow segment of the population uses information and information technology to control and to manipulate the rest. But information and communications technologies do not have to be used that way. With a widely and well educated population, information technologies, linked with communications networks, can be used to help people to learn, to communicate with one another, and to participate in making the kinds of decisions that signficantly affect their lives. Whether they will or not will, of course, depend, in part, on the kind of actions taken by a wide rage of individuals and societal institutions -- the Federal Government, state and local governmental and educational institutions, universities and community colleges, teachers and teaching institutions, workers and unions, businessmen and corporations, and parents and their children.

I hope that this is not too pessimistic a view of our ability to meet the educational needs of all people in an information society. In the event it is, we must be reminded that the Chinese ideogram for the word crisis is made up of two characters: one standing for danger, the other for opportunity. We know that, as a society, we face an educational crisis; it is time now to seize the opportunity.

LOCAL AREA NETWORKS FOR MICROCOMPUTERS IN EDUCATION

Philip K. Piele
University of Oregon*

Introduction

Considering the amount of talking and writing on the topic of local area networks (LANs) for microcomputers, it is not surprising that some vendor public relations personnel have declared 1984 to be "the year of the LAN." [1] Well over 150 LAN vendors have entered the market, according to some surveys, amidst promises of a microcomputer data communications Nirvana. What is surprising is that only a handful of these LAN vendors have installed their products in any significant numbers, and fewer still have been installed in schools.

So why all this frenetic effort by so many companies to sell a product that so far has attracted so few customers? Two reasons serve to provide at least a partial explanation for this seeming madness. First, the number of microcomputers installed in homes, businesses, and educational institutions is expected to exceed 15.5 million by the end of 1987, nearly quadrupling the 1983 installed base.[2] Second, as the microcomputer becomes more ubiquitous in the workplace, people are more interested in sharing information, software, and peripherals. Microcomputers have allowed people to break the computing apron strings with the mainframe or mini computer. Now they want to connect with other microcomputers and also to reconnect with mainframes and minis. The means for accomplishing this connection--physically at least--is supplied by the local area network.

It is predicted that the number of LANs shipped by 1987 will exceed 115,000 units--more than eleven times the number shipped in 1983. Furthermore, the market value of local area networks by 1987 is expected to exceed one billion dollars.[3] Small wonder that so many LAN companies are competing for a niche--even a small one--in the market.

But what about schools? Is there a LAN in their future? According to a recent survey published by the Center for Social Organization of Schools, as of January 1983 approximately 7 percent of this country's elementary schools and 40 percent of its secondary schools had five or more microcomputers, nearly double the number of schools reporting at least five microcomputers six months earlier.[4] So as the base of microcomputers

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*The research for this paper was conducted while the author was on sabbatical leave from January to June 1984 as a visiting scholar with the Institute for Research on Educational Finance and Governance at Stanford University. He wishes to express his deep appreciation to Professors Edwin Bridges, Henry Levin and Russell Rumberger for providing a congenial, supportive, and intellectually stimulating environment in which to work.

expands, the potential application for LANs will expand as well. Thus more and more school districts can be expected to begin exploring the possibility of acquiring a LAN to link their microcomputers together to enhance both their administrative and instructional efforts.

But as a commercial offering, LANs are still in their infancy--more a concept than a product,[5] more questions than answers. This paper will attempt to provide some of the answers to a few of the basic questions about LANs: What are they? What are their basic components? How much do they cost? What are some of their instructional and management applications in schools? What are the current limitations on their use? What course of action should schools follow in acquiring them? Technical jargon will be kept to a minimum. A selected list of books on local area networks is provided at the end of the paper for those who want to learn more about such things as topology (Star, Bus, Ring), media (twisted pair, baseband and broadband coaxial cable, optical fiber), access methods (CSMA/CD, token passing), and network protocols (TCP/IP, XNS).

Finally, it should be clearly understood that what is said about LANs in this paper is merely a "snapshot" of a highly complex, rapidly evolving technology. Between the completion of this paper on June 15, 1984, and my presentation at the conference on August 3, 1984, several new LAN vendors will have entered the market, established vendors will have released new hardware enhancements such as SNA gateways or improved print servers, popular software companies such as Microsoft will have announced LAN compatible products, and on and on and on.

What Is a Local Area Network (LAN)?

There are several definitions of a LAN--some quite technical, others oriented toward the strengths of a particular network design. The definition used in this paper, a composite of two written definitions [5,6] plus some original additions, emphasizes localized data communication links between microcomputers in an office, classroom, or building. A LAN, then, is a privately owned (not FCC regulated), user-managed, commercially available wire or cable-based communication system composed of both physical and logical parts, connecting multi-vendor devices (computers, printers) at high speed in an office, classroom, or building. This definition (and this paper for that matter) excludes broadband local area networks that provide data and video communication links between buildings over distances of up to fifty miles in diameter. It also excludes wide area value-added networks like TYMNET and TELENET that provide, among other things, local data communication links to national information utilities like The Source and CompuServe.

What Are the Basic Components of a Typical Microcomputer LAN Installed in Schools?

The basic components of a typical LAN, for, say, fifteen Apple II microcomputers installed in a high school classroom or lab are as follows:

(1) one network interface card for each microcomputer to connect it to either twisted pair wire or coaxial cable that physically links the various components of the network together; (2) one file server that manages access to a high-speed hard disk storage unit; (3) a hard disk storage unit of from fifteen to twenty megabytes of storage capacity that also includes an integrated or add-on file backup system; (4) a print server to manage access to at least two printers--generally one high-speed dot matrix printer and one letter quality printer; and (5) network software, for example, microcomputer operating systems support, print spooling, and network management.

Some of the more expensive LANs have a file transfer server that allows for the exchange of files between similar networks, while others support the exchange of messages between microcomputers on the network and those located in, say, other classrooms or buildings or in the home.

How Much Does a Typical Classroom LAN Cost?

The average cost (with educational discount) of a classroom LAN supporting fifteen Apple II microcomputers as described above, excluding the microcomputers themselves and the printers and hard disk protection devices such as a surge suppressor or a standby power unit, is currently about $1,200 per student station. Some LANs, like Nestar's Plan 4000, cost about $400 more; others, like Corvus's Omninet, cost about $400 less. Nestar's LAN currently has more features, better performance, and greater potential for expandability than does Corvus's. On the other hand, Corvus's LAN is one of the least expensive on the market, [7] can accommodate a greater variety of microcomputers, and currently has more installed systems in the schools than Nestar's or any other local area network on the market today.

But before you rush out and buy a LAN--any LAN--remember this: No LAN on the market today is a "turnkey" product. You cannot just buy one at your local computer store, take it to school, plug it in to two or more microcomputers, turn it on, and start transferring files, sharing printers, and accessing databases. "If you plan to implement a LAN in the very near future, expect to be a 'guinea pig.'" [5, p. 90] Probably nowhere else in the explosive microelectronic market is there more of a need for one presently to heed the age-old caution of "caveat emptor" than when purchasing a LAN.

What Are Some of the Major Instructional and Management Applications of LANs in Schools?

The linking together of several microcomputers on a LAN provides for several advantages not available from a single microcomputer alone. Consider the following benefits: (1) the shared use of public domain and network- licensed administrative and instructional applications programs; (2) common access to network-compatible database management systems; (3) shared use of expensive peripherals such as letter quality printers and

graphic plotters; and (4) with a few LANs, the use of communications packages, bridges, and gateways to send and receive files between similar systems, to share information between microcomputers using similar software, to send and receive messages (electronic mail), to receive files from mainframe and mini computers, and to link with value-added networks such as TYMNET and TELENET for local access to bibliographic database services such as Dialog and BRS to retrieve information from well-known databases such as ERIC and Dissertation Abstracts.

Several companies are beginning to market instructional software for a network environment, especially one linking Apple microcomputers. For example, Ideal Learning is testing a series of instructional packages for sixth-, seventh-, and eighth-grade mathematics, science, and foreign languages to operate on Corvus's LAN linking Apple II microcomputers; the series will likely be available before the end of 1984.[8] Public domain instructional software developed by the Minnesota Educational Computing Consortium (MECC) is currently running on Nestar's Plan 4000 networks in some San Francisco high schools. Two of the leading companies producing proven computer-assisted instruction (CAI) systems for schools--the Curriculum Computer Corporation (CCC) of Palo Alto, California, and the WICAT Corporation of Orum, Utah--have not yet made their software directly available for use on microcomputer LANs. Nevertheless, CCC at least provides for the ability of schools with IBM PCs to connect them with its mini computer-based system to use its CAI programs.

In the area of administrative applications software for schools, one company, for example, is producing vertical applications software--that is, software designed for a specific group of users--for school attendance, student registration, school scheduling, and grade reporting.[9] Other companies producing similar software for school administrative applications are currently in the process of adapting it for use on one or more LANs.

A limited number of general purpose administrative application programs such as word processing, electronic spreadsheet, database management, and electronic mail are currently available for some LANs. Others are being developed specifically for certain LAN vendors such as Corvus and 3Com. A few popular business application programs such as Wordstar (word processing) and 10-BASE (database management) will currently run on certain LANs and are licensed to do so.

What Are Some of the Current Limitations on the Use of LANs in Schools?

Users of local area networks encounter numerous technical problems such as the following: (1) lack of gateways and bridges to other networks, mainframes, or value added networks; (2) poor, if not impossible, communications between dissimilar microcomputers and networks; and (3) limited migration paths to newer, higher performance LAN systems. Such problems are regularly discussed in data communications trade journals and microcomputer magazines.

Also, there are currently some school personnel and financial problems that may deter the installation and use of microcomputer LANs. They are as follows: (1) a general lack of understanding by many administrators about the use of microcomputers in schools--compounded in many cases, by their own reluctance to use them; (2) a dearth of school district data processing personnel with training and experience in the use of current computer data communications and networking technology; and (3) for many school districts, the acute shortage of funds (a) to purchase a LAN, assuming of course that the network is determined to be cost effective, or (b) to hire or train a person to manage it.

This paper will focus on four major limitations in the use of any microcomputer LAN available on the market today: The need for network management, the shortage of technical support from retail stores and LAN vendors, the lack of multi-user database management system (DBMS) software, and the unavailablity of network versions of popular applications software. The relevance of these limitations to potential users of LANs in elementary and secondary schools will also be emphasized.

Need for Network Management

The management of a local area network for microcomputers is not a trivial process. For the stand-alone microcomputer, software applications in education are numerous and well documented for some machines such as the Apple. The opposite is true for most local area networks. More often than not, one must be able to write special programs in the language of the LAN application software to ensure full utilization of the network. Furthermore, with resource sharing as one of the objectives of the LAN, someone has to set priorities for access to printers, graphic plotters, and other peripherals, as well as manage the output.

With the introduction of most local area networks the heavy workload is at the beginning. It generally takes from two to three months to set up and debug the network. Implementation tasks include creating volumes for users, writing utility programs so that the application software that users are accustomed to running on a single computer operate in the same manner on a network, writing a network users' handbook so everyone understands how to use the full capabilities of the network, and--where expertise is not available from the local retail store or network vendor (as is often the case with LANs)--physically connecting all the parts of the network together and making it work.

Because the introduction of a LAN into the office or classroom "means training personnel, reorganizing procedures, and often learning new programs," [10] a network manager must have a combination of problem-solving skills, systems-programming expertise, and training and experience as a manager. Most people using microcomputers in offices and classrooms have come to rely on them for various on-going and reliable management and instructional applications. Therefore, when implementing a LAN, "one cannot afford such snags as software incompatibility, printer problems, or a

serious disaster such as lost data." [10] Even with a network manager, such problems can and do occur. But without a network manager to help solve them, these and other problems can significantly disrupt the office or classroom environment and even jeopardize the use of the LAN altogether.

Shortage of Technical Support from Retail Stores and LAN Vendors

Closely related to the problem of the need for network management is the shortage of technical support for LAN users from computer retail stores and LAN vendors. Persons responsible for installing most LANs on the market today must have considerable technical training and experience in data communications. "Networking is not a subject for the faint-hearted; there are problems with simply stringing cables--such as signal interference from other electrical products--it requires some degree of sophistication to solve."[11] Don't expect to find such persons at most of your local computer stores. All retail stores offering LANs for sale are glad to sell you the network, but "[a]t present . . . it's tough to find consultants and dealers who have practical experience with networking installations for personal computers. Deciding which networking technology to use is a huge step beyond deciding which computer system to buy--and a matching level of technical sophistication to both sell and install the system is required."[11]

And don't expect very much help from the LAN vendors themselves, either. There is a surprising lack of technical expertise available to the purchaser of a local area network from the company that manufactured it. And few if any companies offer any kind of training for users. Only Nestar currently offers training for new users as well as network managers.

Installation and effective operation of a LAN can be seriously compromised if those responsible for its purchase do not carefully consider the time, technical expertise, and resources that are required. As one purchaser of a popular local area network reports: "We could not have made the decision to use . . . the Omninet system without the assurance that generous amounts of experienced help for the technical business of setting up and maintaining the system would be at hand."[12]

Lack of Multi-User Database Management System (DBMS) Software

Multi-user access to database management system (DBMS) software written for single-user processing is difficult, if not impossible, to use on most local area networks. Very few DBMS programs currently include provisions for concurrent, multi-user access (read/write) to common files. LANs generally provide some form of primitive record locking to prevent more than one person from accessing a database at a time. They do not, however, generally include more sophisticated means to guarantee database integrity common with mainframe and mini computers such as synchronization and queuing.

Also, database security is not available for LANs at a level of

sophistication that most database managers have come to expect with mainframes and minis. Methods for restricting access to certain volumes, to certain records within a volume, or to fields within those records are either totally missing or only partially available on most LANs on the market today. Can LAN vendors guarantee that a student will not have access to his or her grades, but that a teacher, or counselor, or principal will have such access? Regrettably, the answer is no. Can a teacher have "read only" access, say, to his or her personnel file, but be prohibited from accessing a field containing letters of recommendations, where the right to see such recommendations had been waived? Again, the answer is no.

Much remains to be done with respect to the protection of databases containing sensitive personnel files or financial records from unauthorized access and alteration. Some vendors of popular DBMS programs, however, have begun responding to the basic requirement that they "design [programs] to be accessed by more than one user at a time, with file and/or record-locking to prevent the clobbering of files."[13]. Microrim (R:BASE SERIES) and Ashton-Tate (dBASE II) have announced multi-user versions of their programs for specific LAN vendors. Other database system vendors are expected to announce network-specific versions before the end of 1984. In addition, established application software vendors such as Visicorp and Microsoft are expected to announce network versions of their software in early 1985.

Unavailability of Network Versions of Popular Applications Software

In addition to the limitations on the availability and use of popular database management systems software for the local area network, LAN versions of popular word processing programs like BankStreet Writer or integrated applications software like 1-2-3 are currently not available. To legally use either of these programs on a local area network, one is compelled to buy one package for each microcomputer on the network. To do otherwise is to violate section 117 of the Federal Copyright Act of 1976 which makes

> [i]t . . . [im]permissible [for one] to take a program that was not designed to copy itself in a network, and to distribute it to the various personal computers in the network. For example, downloading Wordstar or VisiCalc from a master disk into other personal computers connected in a network for many simultaneous users is not legitimate, because that proliferation is not designed into the program--even if the use of the program is entirely internal to each computer and the code never sees the surface of a magnetic disk.[14]

The International Council for Computers in Education has issued guidelines for the use of copyrighted software on a local area network. These guidelines represent more hope than reality, however, with respect to the copyright issue. The hope is that software vendors will begin to acknowledge the growth of local area networks and supply software at a reasonable price for use in a multi-user environment--especially in schools.

There is also the hope that schools in turn will honor the copyright limitations on single-user software while trying to reach accommodations with software companies--through some sort of licensing agreement--for network applications.[15]

One local area network vendor (3Com) has proposed a plan to overcome the reluctance of popular business applications software vendors such as 1-2-3 to adapt their software for use on local area networks. 3Com's "plan calls for the development of separate networking-software packages, each designed specifically for a given number of personal computers. The networking package would be priced according to the number of personal computers that it was designed to serve and the estimated amount of sales that would be lost due to software privacy of individual packages."[16] A device to prevent illegal duplication of the software would also be included with the networking package.

Some software vendors, on the other hand, are taking the initiative to produce software for local area networks. A company called Applied Intelligence in Mountain View, California, is reported to have a contract with several microcomputer companies for LAN software it is developing to run on CP/M and MS-DOS operating systems.[17] There are also reports that major software vendors such as Microsoft, Ashton-Tate, Software Publishing, and Visicorp are jumping into the local area network market, either with networks of their own (as is the apparent case with Microsoft) [18] or the rewriting of single-user software to operate effectively on the network.

It should be emphasized, however, that until popular applications software is available in network versions, or unless an agreement can be reached with the vendor for use of the software on a network, it is illegal to buy a single copy of a copyrighted software package and to copy it to a hard disk for use by several microcomputers on the network.

So What Should Schools Do About LANs?

The best advice for schools right now is to do what they have historically excelled at when it comes to adopting new technology: very little. At least at this stage in the evolution of LAN technology, it would be unwise to commit large sums of money (for those few districts who have large sums of money) for the purchase of LANs. If your district does have some money available, however, the purchase of a small, low-cost startup or prototype network would be an excellent way to get some hands-on experience with LANs in your own school.

If you want to learn more about what LANs are and what they can and cannot do and what they might be able to do by the end of this decade, you could begin by doing some reading among the sources listed as references and in the selected annotated bibliography at the end of this paper. You might also want to explore the possiblity of attending a workshop or seminar on the topic. But be careful in deciding which one to attend. Many are very expensive (tuition for a three-day seminar generally ranges from $800 to

$1,000) and tend to be quite technical. The least you should do now is to begin assessing the present and future communication needs of your district, including not only data communications but also voice and video communications as well.

If you start the process of planning, familiarity, and training now, in two or three years you will likely be ready to purchase a full-scale local area network for both instructional and management applications. Keep in mind that by then the average cost of the network may be approximately $150 per student or work station instead of the current average cost of approximately $1,200. Network-based software for instruction and management will be more readily available and, it is hoped, less expensive. LANs should be standardized around the technology of two or three major vendors; they will be less complicated and easier to install and use; and their flexibility and compatibility will be significantly improved.

References

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5. Tony Webster, "Local Area Networks Overview," Office Automation & Word Processing Buyer's Guide. New York: McGraw-Hill, 1984, p. 73.

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17. San Jose Mecury News, February 21, 1984.

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Selected Annotated Bibliography

Cheong, V.E., and R.A. Hirschheim. Local Area Networks: Issues, Products, and Developments. New York: John Wiley and Sons, 1983.

The most scholarly book on the list, but nevertheless contains excellent chapters on evaluating and implementing LANs, with materials not found in other local network books. The only book I have read that discusses the impact of LANs on management style.

Chorafas, Dimitris N. Designing and Implementing Local Area Networks. New York: McGraw-Hill, 1984.

A very comprehensive, but technically oriented book. Excellent, though somewhat dated, discussion of the components and operation of several commercially available baseband and broadband LANs. Not a book to start with.

Derfler, Frank J., and William Stallings. A Manager's Guide to Local Networks. Englewood Cliffs, NJ: Prentice-Hall, 1983.

The least technical book on the list. Written for administrators who want to learn more about local area networks and how to use them in an office enviornment. Excellent chapters on planning an office automation system and buying a local area network. A very readable, well-illustrated, and practical book.

Introduction to Local Area Networks. Maynard, MA: Digital Equipment Corporation, 1982.

A moderately technical, though clearly written discussion of the basic elements (topology, media, access) of local area networks. Has an excellent chapter on the Ethernet local area network.

Jordan, Larry E., and Bruce Churchill. Communications and Networking for the IBM PC. Bowie, MD: Robert J. Brady Co., 1983.

Written for IBM PC owners, this book contains several very technical chapters on data communications. Also has a single, comprehensive chapter on LANs, with detailed information about three baseband networks. Authors speculate on future developments in communications for the IBM PC.

MANAGING THE INTRODUCTION OF COMPUTERS INTO EDUCATION

S.J. Thiessen
Director, Computer Technology Project
Alberta Education

A. Introduction

In this paper I would like to discuss a number of aspects related to the efforts of one Canadian Department of Education to provide leadership in the exciting educational computing area. This presentation will be a brief discussion of some issues related to the introduction and effective use of computers in schools. Finally, a brief Computer Technology Project status report, and a look at the future will end the presentation.

B. Context

The Province of Alberta's Department of Education, usually known as Alberta Education, controls the Program of Studies for all curriculum from Kindergarten through Grade Twelve. Each of the approximately 150 school districts in Alberta follows the provincial government curriculum in their classrooms. If teachers at a particular school wish to present a unique curriculum, they request Departmental approval. There are approximately 450,000 students being taught by 27,000 teachers in this province.

In addition to approving the Program of Studies, the Department of Education coordinates the evaluation of learning resource materials. During the past years, the Educational Products Information Exchange (EPIE) process has been used for textbook adoption purposes. Products given excellent ratings receive the designation "prescribed". In addition, two other ratings are given: recommended and supplementary.

For those materials receiving a prescribed rating, Alberta Education's School Book Branch will purchase them in substantial quantities. Forty percent discounts are then offered to school districts. Recommended materials are sold at a 15 percent discount, while supplementary materials are not discounted, although bulk purchase savings are passed along. The discounts are subsidies
funded by the government.

These program directives do not mean teachers have no professional input into their instructional programs. It is entirely appropriate for the instructor to make the concepts relevant by altering the presentation strategies, and through the use of media and appropriate reference materials. However, the general content areas are specified.

Finally, about 65 to 75 percent of the educational funding in Alberta is provided through the provincial government from general tax revenues.

C. Background

Alberta Education has been involved in the area of educational computing for about ten years, initially through research projects and studies, and more recently through the development of computer literacy curricula, research and evaluation studies, the Minister's Task Force on Computers in Schools, and the Computer Technology Project.

During the 1970s all of our activities could be characterized by the notion of "getting our toes wet". That is, we dabbled at the periphery, but did not get serious about the issue. As is the situation throughout North America, the development of micro-circuitry led to increasing teacher interest in making use of this modern tool within their instructional programs.

As a result of the technological developments and the acceptance and use of microcomputers by hobbyists, families, and businesses, considerable political pressure was being placed on the provincial government to "do something" about microcomputers in our schools. Many school districts were unwilling to commit funds to the purchase of any microcomputers until they were certain what the provincial government would or would not do. Also, many districts are very small, and would not have the capability of searching for, evaluating and selecting appropriate microcomputer software for use in their classrooms.

In October, 1981, the Honourable David King, Minister of Education, announced a number of government initiatives in the field of educational computing. These were: development of computer literacy curriculum at the elementary, junior and senior high school levels; investment of funds for research and evaluation studies in this field; the decision to standardize all Alberta Education activities on one brand of microcomputer; the formation of the Computer Technology Project; and his intention to establish a Task Force to make recommendations about future educational computing activities.

D. Computer Literacy Curriculum

A computer literacy curriculum has been developed as part of Alberta Education's efforts to provide leadership in educational computing. It has always been understood that the formal computer literacy curriculum is to be a temporary activity, designed to introduce students to computing. However, we also have maintained that the best method for introducing students to computing is to use computers as educational tools within the instructional program. By making every-day use of the equipment, students will quickly become 'computer literate'.

During the introductory phase it is very difficult to provide sufficient computers for each student to make daily use of the equipment as an integral part of the instructional process. Therefore, while school districts are acquiring more equipment, the pupils have been placed in a less than ideal program.

Our plans are to phase out the computer literacy curriculum within the next three or four years. Because developing, pilot-testing and implementing a curricular program is a two year process, any computer literacy curriculum is out-of-date by the time it is implemented. Another reason for moving away from computer literacy to using computers as functional tools is that students do not need computer literacy; they make effective use of the equipment more quickly than do adults.

E. Research and Evaluation

Through the Planning Services Branch of Alberta Education the government has funded a variety of planning studies and projects. During the 1970s these studies included a pilot-test of a locally developed mainframe mounted Computer-Managed-Learning (CML) system; a review of the literature in the Computer-Assisted-Instruction (CAI) area; and a number of small pilot-project studies. In the late 1970s, we tried out the then new microcomputers in classrooms.

By conducting the research studies, we were able to develop contacts and expertise in various aspects of educational computing. During the time these studies were underway, a number of Alberta Education personnel were actively involved in discussions about related policy issues. Therefore, by the time senior management was ready to make some policy decisions, many of the issues had already been analysed and were ready for presentation.

F. Hardware Standardization

Prior to the announcement of the Computer Technology Project and the related activities, many educators were making numerous inquiries to Alberta Education personnel regarding which microcomputer to buy for their classrooms. We had been investigating this matter for some time with a view toward making policy recommendations.

Obviously, the first question is whether or not to set a standard. Questions such as: what advantages would there be to having a standard in place? and what would happen if no standard were set? were critical to these discussions.

Fortunately, a number of school districts throughout North America already had some experience on both sides of the question by the time we seriously were asking these questions. If courseware considerations form the basis of educational computing decision-making, then a decision to standardize makes logical sense. Because good quality courseware is difficult to find; because people with expertise in the educational use of a variety of microcomputers were not available; and to provide educational computing opportunities to students as equitably as possible, we decided to standardize on one microcomputer system.

Another issue we considered was the intended use of the computers. If computer literacy is the major goal, then any cheap computer will suffice. However, if CAI, administration, and CML are being considered, then courseware and software issues become much more important. In fact, our decisions were based on the assumption that courseware was the most important variable.

Upward compatibility then becomes crucial. School districts that have invested in a particular microcomputer want to maximize that investment. Should the new version of that computer not be able to use software for the previous version, much of their investment in software has been wasted. Buying new software to run on new equipment would be poor use of public funds.

After considerable discussion, it became apparent that there were not that many computers from which to choose. Only about five jurisdictions had made a standardization decision. Some of those decisions were more a result of good bidding than serious educational decisions. We consulted them to determine their perceptions of the advantages and disadvantages associated with their policies.

Finally, a decision was made to standardize on Apple II+. This particular brand was chosen because: there was more educational software available in Apple II+ format than all the other microcomputer brands combined; the model had been used in schools for almost two years, and most of the districts reported excellent results; service for the computers was readily available; although slightly more expensive than some of the other brands, there was some element of comptetion since two companies were able to bid on the contract; senior management of the manufacturing company were committed to upward compatibility of subsequent versions of the Apple II; the computer was reliable, versatile, and expandable; there were numerous companies developing peripherals and software for that computer; and no other microcomputer could match all of those characteristics.

Alberta Education did not direct school districts to purchase any particular microcomputer. What we announced was that all of our courseware evaluation activities would be for Apple II+ format only. At the present time about 65 to 70 percent of the installed base in Alberta schools is Apple II format.

Although our decision is continually under review, we do not envision changing to another brand. If changes are made to this decision, it will probably be to add another brand to our list of courseware evaluation activities.

G. Computer Technology Project

This Project was started at the beginning of the 1981-82 fiscal year, and will run to the end of the 1984-85 year. It's major goals were to evaluate courseware; coordinate inservice; maintain communications with the technology field; and communicate information to the Department. We also were to maintain liaison with other Education Departments in Canada.

The issue of good quality educational courseware led to the formation of the Courseware Clearinghouse, a major part of the Computer Technology Project. Clearinghouse staff search for courseware, and evaluate materials from technical, pedagogical, and Alberta curriculum perspectives.

Operation of the Clearinghouse began with hiring a Manager in the sumemr of 1982. Initially we searched for courseware evaluation systems already in place. Considerable credit goes to the MicroSIFT evaluation group at the Northwest Regional Educational Laboratory in Portland for the work they have done in this area. Their Coordinator of Courseware Evaluations trained about 40 Alberta educators in their evaluation process.

Because the purpose of our evaluations is to provide classroom teachers with information which can be used to make a purchase decision, we began developing a unique courseware evaluation process. Ideas from the MicroSIFT, EPIE, and other evaluation systems have been incorporated into our own distinct set of procedures.

Our evaluation process is to search for courseware packages in a specific subject area. We began with mathematics because the Grade One to Twelve math curriculum was being revised at the time. As we have been able, courseware evaluators in additional areas have been trained. Present subjects that are being evaluated are accounting, business education, computer literacy, library skills, mathematics (English and French versions), science, special education, and word processing.

The first step in the evaluation process is to solicit examination copies of all courseware in Apple format for a particular subject area. Our data base includes entries for approximately 450 distributors.

Upon receipt of the courseware, the Clearinghouse staff screens the materials to determine whether or not that package appears to have potential use in Alberta classrooms. If it seems promising, it is sent to three classroom teachers for an in-depth evaluation. The three teachers evaluate the package independently, with the last teacher synthesizing the three reports. The teachers use these packages with their students as an integral part of the evaluation process. Should the package appear to have good applicability, it is then sent to a learning resources committee in Alberta Education to determine how well it fits the Alberta curriculum. Depending upon their decision, the package is rated as a prescribed, recommended or supplementary resource.

Evaluators are selected on the basis of experience, subject matter expertise, and successful completion of a two-day evaluator training workshop. The teachers are paid for the time they spend doing these evaluations.

For the materials rated as prescribed or recommended, the government's School Book Branch will negotiate a bulk purchase of the particular courseware package, and will subsidize the sale price for authorized purchasers. The subsidy for prescibed materials is 40 percent; for recommended resources it is 15 percent.

As of May 1, of 1300+ package titles, slightly fewer than fifty were authorized in any way. While that statistic may seem unduly low, many developers have commended our approach, and have indicated that they have directed the authors to make changes in the programs to remove weaknesses we have found.

Our inservice activities comprise the other major portion of the Computer Technology Project. The Inservice Manager's responsibilities are to coordinate the planning, development and delivery of inservice seminars for school systems requesting this service. During the initial phase of the Project, most schools did not have access to any computers, so we purchased 40 microcomputers which are transported to seminar locations.

During the 1982-83 school year Project staff conducted over 250 seminars. Most of these were done by the Inservice Manager. For computer novices, these seminars usually began with a variety of familiarization activities. Some initial experiences are provided to briefly describe the potential applications of computers to classrooms.

As more and more teachers have gained computer experience, the content of the inservice workshops has changed to topics such as courseware evaluation, administrative applications, courseware availability, networking, LOGO in the classroom, and new developments in the high technology field. Teachers are very anxious and willing to learn about computers, and their effective application in the educational setting.

Obviously, one individual cannot provide sufficient inservice sessions for all the teachers. We have trained a number of people capable of providing the workshops requested. If the Inservice Manager is unable to conduct the session, these other people lead the workshop.

Even though the nature of the seminars is changing, there still are many teachers who have not become familiar with computers. Many teachers are not yet making effective use of computers as instructional tools, but are diligently working to upgrade their skills in this area.

H. Minister's Task Force on Computers in Schools

Even though the technological changes in the computer industry are occurring more rapidly than ever before, and in spite of the fact that a variety of policy initiatives were implemented, the Minister of Education also wanted a non-governmental group to review the situation and make recommendations to him about future provincial educational computing policies and directions.

In July, 1982, the thirteen member Task Force began deliberations, and it's report was issued one year later. Members of the Task Force represented a wide variety of groups: teachers; school board members; two government departments (Alberta Education and Alberta Advanced Education); the Curriculum Policies Committee; school superintendents; post-secondary institutions; the data processing industry; Home and School Association; and two members-at-large.

During the year, the Task Force had about fifteen days of meetings. They also visited some schools throughout Alberta. Task Force representatives visited schools in California, Minnesota and Texas while attending educational computing conferences in those states. A survey of all Alberta schools was sent out to try to ascertain the numbers and uses of microcomputers in our schools. Results indicated that there were almost 4,000 micros in Alberta classrooms, as of March, 1983.

All of this work resulted in a report containing 48 recommendations for future action. These recommendations were sorted into seven broad categories: students and curriculum; teacher training; courseware; hardware; planning; organization; and funding.

The first recommendation was that by 1985 all students in Alberta schools shall have regular access to a computer learning station. In addition, a review of the Program of Studies should be initiated to introduce curriculum components related to technology; to adapt the sequence, structure and design of the Program of Studies to accommodate continuous student progress and to encourage a personalized, self-directed learning approach.

Recommendations were made regarding preservice, inservice, graduate training and continuing education for teachers. For example, we recommended that by 1986 all students graduating from our Faculties of Education be required to have completed a computer literacy course. For teachers coming to Alberta, a standard 40-hour computer literacy course should be completed prior to receiving a teaching certificate. Also, Faculties of Education should offer major and minor specializations in educational computing, as well as graduate programs in that field.

It was also recommended that Alberta Education offer financial incentives to enable practicing teachers to undertake graduate level training in educational computing.

A teacher inservice program should be developed and funded by the Alberta Government, local school districts and the teaching profession, according to the Task Force. Every practicing teacher and administrator ought to be given the opportunity to learn the fundamentals of educational computing, and to put those ideas into practice where possible. Implementation is to begin within the 1983-84 school year.

Regarding courseware, the government was commended for work already begun through the Clearinghouse and the School Book Branch. They suggested that these efforts be expanded. For the courseware development industry, the government should encourage courseware development through incentives, funding assistance and shared research. A series of related recommendations were made to encourage copyright law revision, marketing assistance for private sector development efforts, and development assistance for special education courseware development.

For hardware standards, the Task Force stated that Alberta Education ought to annually review the hardware standard already developed, and that buy-agreements be negotiated with manufacturers who meet the established hardware criteria. School districts should buy their computers from local dealers to support the business community, and to obtain better service.

With respect to educational standards, we recommended that there be a minimum of one computer learning station for every eight students in a school. For CAI and business education applications, there should be one computer laboratory for every eight classrooms at the junior and senior high school levels.

The Task Force believed that the future direction in educational computing would be toward local-area-network (LAN) systems. It was suggested that a central data bank be established to encourage and support the LANs. Network standards should be developed soon to enable school jurisdictions throughout Alberta to communicate with each other and with centralized data bases.

Development of computer peripherals for the handicapped student should be encouraged by Alberta Education. A variety of submissions to the Task Force suggested that the potentially greatest benefit of computer use is to be found with their use by the mentally and physically handicapped.

Five recommendations were made relative to planning for the future. For example, Alberta Education ought to: provide bold and decisive leadership in educational computing; develop a comprehensive strategic provincial educational computing plan to be reviewed annually; and Alberta Advanced Education should develop a plan to implement those recommendations that have a bearing on preservice and graduate teacher training programs. These plans are to be developed in conjunction with post-secondary institutions and this planning should be initiated as soon as possible.

Another recommendation was that each school district in Alberta should develop a multi-year educational computing plan. A specific individual within the school district should be designated to coordinate the development and implementation of the educational computing plan and the related activities.

One of the major issues surrounding this area is funding. The Task Force believed that the provincial government should fund 85 percent of the costs of implementing these recommendations. If the recommendation to place one computer learning station for every eight students were to be fulfilled, a total of approximately 48,000 additional microcomputers would be needed.

Finally, there were some recommendations that suggested a number of organizational actions on the part of Alberta Education. For example, an annual educational computing conference should be sponsored by the government. In addition, advisory committees should be created to enhance and formalize the communications between all sectors of the educational community.

1. Response to Task Force Recommendations

Copies of the final report of the Minister's Task Force were circulated to all school districts and schools in Alberta. In addition, many copies were sent to public libraries, the media, and post-secondary institutions. Responses to the recommendations were welcomed.

About 35 responses were received, most of which were very positive. The Government of Alberta has responded by designating funds for inservice in three priority areas, one of which is computers. School districts are being given the opportunity to receive matching grants for hardware purchased after January 1, 1984. The computer purchases are designated primarily for upgrading business education laboratories. However, we believe that many school districts will purchase new equipment for business education and use present business education computers in other areas. Slightly over $31 million has been allocated for this activity, to extend over the next three years.

Coupled with the monetary action, we have indicated that every school district shall prepare a five-year educational computing plan. Major components of these plans are to indicate: educational computing goals; criteria for success; involvement of all levels in preparation of the plan; how the computers are to be used; where service will be obtained; how funds will be designated for purchase of software; facility modifications necessary; planning for future technological changes; and most importantly, how students will benefit from these activities.

In addition, the functions being performed by the Computer Technology Project are to be maintained within the operations of the Department of Education. These functions will be regularized during the 1984-85 fiscal year.

J. Conclusions

There are many issues that impact decisions about the educational use of computers in schools. Alberta has attempted to address some of the more important issues in order to provide leadership and direction for school districts.

The impetus for our actions may be summed up in a statement from the Task Force report (p. 3):

> Our discussion of educational computing has been guided by an abiding concern for our children and their future. Every recommendation that we have made recognizes our shared responsibility to prepare the children of Alberta for a future which will be significantly different from the present. Much of the well-being of future generations and prosperity of our province depends upon this preparation.
>
> We are on the verge of technical, economic and educational change of an order not seen before. The question is not whether we can afford the effort and cost required to introduce computers into our schools. Rather, the question is whether we can afford NOT to do so.

Computers in Schools, the report of the Ministers Task Force on Computers in Schools, Edmonton, Alberta Education, July, 1983.

SPECIAL INTEREST SESSIONS

"So What's a School District Computer Education Coordinator To Do?"

Greg Woods

Computer Coordinator

Klamath County (Oregon) School District

During the 1982-83 school year, while on sabbatical leave at the University of Oregon, I gambled that my employing school district would create the proposed position of computer coordinator and so, planned my program with that potential position in mind.

Electing to complete the graduate program via the internship/examination option, I scouted for a topic which would be of value to me, professionally, and also of possible value to my school district. Intending to tie these requirements together with the academic program, I proposed to research the role and responsibilities of the emerging job of school district computer coordinator. I discovered, via cursory research, that there were few full-time people occupying such a position and even fewer existing published job descriptions.

An idea emerged that the attitudes held by people as to the responsibilities of a school district computer education coordinator are very personal "gut feelings". Each person has notions of what a coordinator should do but they tend not to be founded on empirical evidence. Chiefly, that may be due to the dirth of evidence existing in the fledgling computer education field. Since that initial impression I have developed an idea, based on experience in the position, and that is, "Do it (whatever the dictator's personal preferences based on his individual background might specify), and have it done by yesterday. And, by the way, don't spend any money doing it".

I proposed a summer internship with the I.C.C.E. to investigate and report the perceptions of teachers, administrators, school board members, computers in education 'experts', etc., of the appropriate roles and responsibilities of a school district 'computers in education coordinator'. The investigation was not to include administrative data processing, but might cover computer-managed instruction and student records.

The investigative process was to involve a questionnaire, interviews, a manual literature review and a computer search of data bases.

Product generation was to include a data file with a compilation of findings. Documents were to consist of a summary of findings, a job description or alternate job descriptions, and an in-depth application of findings to my school district. Application of the findings would entail a proposal to the school board and administration regarding the developed job description.

Help in designing the questionnaire was generously provided by Dr. Meredith Gall of the College of Education, University of Oregon. An opportunity to field test the survey questionnaire form was made available by Dr. David Moursund and his students in a graduate computer education seminar. University of Oregon Summer 1983 Computer Education Conference attendees and personal contacts also aided me in the form revision.

The revised survey was distributed to the members of the Northwest Council for Computers in Education and to teachers, administrators, school board members, etc. in my district. The total number of returned questionnaires was 230.

The majority of respondents held jobs in education from primary grades through higher education assignments including, but not limited to, classroom teachers, principals, media specialists, directors, teaching specialists, coordinators, division heads, superintendents, ESD personnel, professors, state department persons and teacher trainers. Also included were people from private business, parents, students and various committee members.

Of the people who responded to the survey 145 requested that they receive a summary of the job description survey. Hopefully, the two job descriptions which follow and the results of the questionnaire which I will present during his third Summer Conference "The Computer: Extension of the Human Mind" will satisfy interested respondents.

There was one comment which occurred more than any other. Many respondents pointed out that a 'School District Computer Education Coordinator' needs to be a people-oriented person. My preconceived opinion was that such a person would need to be primarily task-oriented. After one year on the job my observation is that they were absolutely 'right on'.

Following is the job description which I wrote for my present position last September prior to compiling the survey results. It is a synthesis of a review of the literature, personal interviews and a field test of the questionnaire.

COMPUTER COORDINATOR'S JOB DESCRIPTION

I. QUALIFICATIONS:

A. Graduate work in computer instruction and/or Educational (Instructional) Technology.

B. Demonstrated knowledge of microcomputers as they are used in public schools. Knowledge of microcomputer hardware, software and languages.

C. Successful teaching experience at the elementary and/or secondary school levels.

D. Communication skills, written and oral.

E. Hold an Oregon teaching certificate.

II. RESPONSIBLE TO:

Director of Media Services (note: This is specific to my particular school district's structure.)

III. EVALUATION:

Evaluated by the Director of Media Services in accordance with the adopted teacher evaluation program. (note: My proposal to make the position administrative in accordance with recommendations gleaned from my research was not accepted.)

IV. FUNCTION:

The Computer Coordinator is responsible for the overall organization and direction of the school district's computers in education program.

V. JOB GOAL:

To continually improve the computers in education programs of the school district.

VI. TERMS OF EMPLOYMENT:

200 days contract.

VII. PERFORMANCE RESPONSIBILITIES:

A. Maintain a position of current knowledge of the field of Computers in Education.

B. Work with district personnel in the development of curriculum related to student uses of computers.

C. Coordinate school and district instructional uses of computers.

D. Evaluate and recommend training programs to insure the effective uses of computers.

E. Organize and conduct staff training in the instructional aspects of the computer literacy curriculum.

F. Take a leading role in establishing procedures for the educational applications of computers.

G. Make budgetary recommendations to the Director of Media Services regarding the computer education program.

H. Cooperate with principals in the development of school building computer education programs.

I. Recommend the purchasing of new hardware, software, and courseware with administrators, teachers and the Director of Media Services.

J. Insure the accurate cataloging of information re all computer-related materials including additions and deletions by maintaining records and working with the staff at the district Instructional Media Center.

K. Perform other duties as assigned by the Director of Media Services and district Superintendent.

If given the opportunity to rewrite the above job description, there are some changes which I would recommend. They would include lengthening the contract year, reporting directly to the Superintendent and moving the position off of the teachers' schedule - salary and some contract language.

The following job description is based upon a summary of the returned questionnaires in the survey. Items are listed hierarchically from highest to lowest priority for the responsibilities and qualifications

of a school district 'Computer Education Coordinator' as identified by the survey results.

SUMMARY OF JOB DESCRIPTION for COMPUTER COORDINATOR

(Based on Survey Responses)

JOB RESPONSIBILITIES:

1. Provide for staff development in the uses of computers in education.
2. Coordinate implementation of computer programs in the schools.
3. Assist schools in the selection and implementation of computer software.
4. Keep up with hardware and software trends via vendor contacts, the literature, meetings, trade shows, etc.
5. Recommend policy on district selection and uses of microcomputers and peripherals.
6. Develop and implement evaluation of computers in education programs within the district.
7. Recommend resources, agencies, and personnel to assist in the solutions of district problems pertaining to the uses of microcomputers and related technologies.
8. Design and implement a software distribution system.
9. Formulate and monitor a budget to support district computer education efforts.
10. Review new instructional (technology) delivery systems for district consideration.
11. Develop and maintain a library of reference materials for district staff use.
12. Establish a computer networking system to link the buildings within the district.
13. Edit a 'computers in education information newsletter' for distribution throughout the district.

QUALIFICATIONS:

1. Knowledge of microcomputer hardware and software as they are used in elementary and secondary schools.
2. Literacy (functional programming skills) in at least BASIC.
3. Experience in computer education for both instruction and management.

4. A minimum of 5 years successful experience (or equivalence) as a teacher at the elementary and/or secondary levels.
5. Active association with a professional organization related to the uses of computers in education.
6. Graduate work or equivalent experience in computer education or Instructional Technology.

After one year working in the field holding the position described above, I have many thoughts concerning what I perceive to be the requisite responsibilities and qualifications if one is to expect success. There is not sufficient space to address them here. That shall be the focus of my presentation.

Interactive Video and the Mentally Handicapped: A Research and Demonstration Program

Philip Browning and Gary Nave[1]
University of Oregon

Computer technology to serve the handicapped is a subject of increasing popularity in the fields of Special Education and Rehabilitation. Evidence of this rapidly growing interest is reflected, in part, by the publication of books, monographs, and conference proceedings on the topic (e.g., Hagen, 1984; Roehl, 1984; Budoff, in press; Goldenberg, 1979; Taber, 1982) and special issues being devoted to the area by periodicals such as Byte (1982), Computer (1981), and Exceptional Children (1982). Furthermore, there is a newly established Annual National Conference on Technology in Special Education, sponsored by the Council for Exceptional Children. In essence, these and many other related activities confirm that handicapped people can and are being significantly aided by the revolution in microcomputer technology.

One well recognized use of microcomputers is in the special education of the mentally handicapped, and herein lies the focus of this paper. Specifically, the reader is introduced to a research and demonstration program designed to explore the application of Interative Video with mentally handicapped adolescents and young adults.

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[1]Dr. Browning is Professor in the Division of Special Education and Rehabilitation and Research Director of the Rehabilitation Research and Training Center in Mental Retardation. Mr. Nave is a Research Associate at the R-T Center.

Interactive Video

Interactive Video, also referred to as computer assisted video instruction (CAVI), is one of the many promising educational uses of microcomputers. It represents the merging of two powerful technologies, computer and video, into a new medium which many leaders in business and education consider to be a most promising instructional technology.

CAVI is a merging of video presentations into computer assisted instruction (CAI), which has been defined as: " . . . an interactive learning environment in which the computer presents and responds to information given to it by the learner for the purpose of facilitating performance on the part of the learner" (Winters, Hoots, & East, 1978, p. 4). The computer program provides for the student interaction just as in CAI, but unlike a CAI program, it also controls the playing of various video segments depending upon student inputs. Thus, different visual and auditory input can be provided to a student depending upon how he or she responds to a question (i.e., correctly or incorrectly).

A CAVI system consists of: (1) a microcomputer, (2) a videotape recorder (VTR) or a videodisc player, (3) a computer-video player interface card, and (4) a video monitor. These four components, when properly connected, allow the user to run CAVI software. This software consists of a computer program and associated video on either tape or disc.

Nowhere is the potential benefit of Interactive Video greater than with the mentally handicapped because of its instructional learning features. Some of these characteristics include its ability to (1) present small, systematic units of material; (2) provide repetition as required by the

student; (3) make small or large changes in the level of difficulty; (4) present routine skill training in an attractive format which minimizes extraneous distractions; (5) provide both immediate and positive feedback during learning; and (6) provide individualized instruction (Macleod & Overheu, 1977; Thorkildsen & Williams, 1981). An additionally attractive feature is that the use of video minimizes the need for the learner to read.

This technological approach to learning is particularly appropriate for preparing handicapped adolescents for transition from school to community, in that "real life" situations can be portrayed through video. In-class simulations, coupled with the instructional assistance of the computer, serve as a potentially effective medium for visually and instructionally placing students into the community setting for which they are preparing.

A Research and Demonstration Program

The University of Oregon Rehabilitation Research and Training Center in Mental Retardation is conducting a 5-year project (Browning, 1982) to research and demonstrate the utility of Interactive Video for teaching mentally handicapped adolescents important community adjustment skills. Specifically, the goals of this project are to: (1) prepare a state-of-the-art document on computer technology and the handicapped, (2) investigate the conditions under which mentally handicapped persons optimally learn through the use of Interactive Video, (3) develop community-referenced courseware for this target group, and (4) implement a dissemination/utilization plan. Figure 1, which depicts these goals and

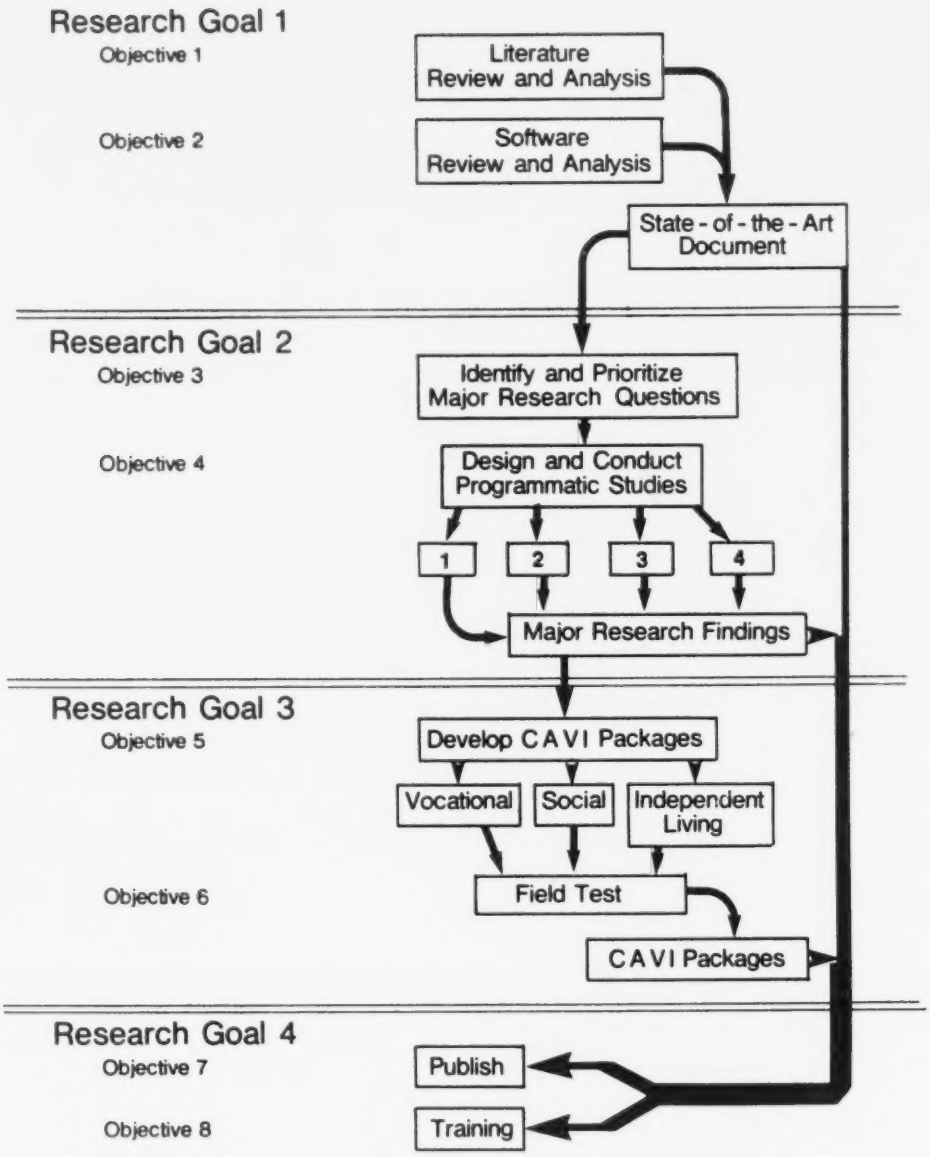

Figure 1

Research Goals and Objectives

their related objectives, reflects the programmatic nature of the project. The remainder of this paper "highlights" some of the completed activities with respect to these areas.

Goal 1: State-of-the-Art

Two manuscripts have been published which address this goal of documenting the state-of-the-art regarding computer technology and the handicapped. In both cases, the following model was developed to serve as a blueprint. This framework is general and does not delineate in detail the full range of fundamental computer usages. For example, 12 specific applications of microcomputers have been identified for usage in education (Watts, 1981) and rehabilitation (Vanderheiden, 1981). The purpose of this generic

	Education			Rehabilitation		
	Instruction		Management	Functional Aids		
	Student/ Client	Teacher/Service Provider			Communication	Independent Living
Physical Disability						
Developmental Disability						

Figure 2

A Generic Model of Computer Applications for the Handicapped

model is to simply represent the broad areas of computer application with this target population.

The first manuscript pertaining to this goal is entitled Computer Technology for the Handicapped in Special Education and Rehabilitation: A Resource Guide (Nave, Browning, & Carter, 1983). It is a comprehensive bibliography comprised of 191 annotated references drawn from more than 60 different periodicals, books, monographs, and conference proceedings. The subject index includes the application areas shown in Figure 2. Furthermore, these content areas are subdivided according to disability (e.g., autism, cerebral plasy, deaf, learning disabled, quadriplegic, mentally retarded, etc.). The second manuscript (Browning & Nave, 1983) uses the same generic model (see Figure 2) and provides a literature "profile" on comptuer technology for the handicapped.

Goal 2: Research

The first completed study (Carter, Browning, Nave, & White, 1984) was designed to determine if (1) interactive video was an effective instructional medium with mildly handicapped adolescents, and (2) different types of informational feedback affected learning performance (e.g., error correction). Twenty-six Ss were assigned to two groups which were equated on a pretest score and age. Their respective mean IQs were 58 and 60. The learning task consisted of responding to a 10-item true/false learning module on budgeting. Stop criteria for each item was two consecutive correct responses or a total of three incorrect responses. Items were presented iteratively to minimize simple memorization of correct responses.

The computer used in this study was an Apple II+ microcomputer with 64K bytes of random access memory and two floppy disk drives. The VTR used was a Panasonic NV-8200 1/2" industrial model and the interface card was a BCD 450 purchased from BCD Associates in Oklahoma City, Oklahoma.

A learning station was designed and built to provide an efficient learning environment for students to interact with the CAVI system. The Apple II+ and a color TV monitor were placed in front of the student inside the station. The tape recorder was placed out of sight on a fold-out table secured to the back of the learning station. This minimized the amount of visible equipment and helped to muffle the operating noise of the VTR.

The results indicated this medium was effective in that significant learning occurred for both groups. However, there were no differences between Ss introduced to the more extended (Group A) versus briefer (Group B) form of informational feedback.

Goal 3: Courseware Development

During the past year, project staff have developed an Interactive Video curriculum designed primarily for secondary-aged handicapped students. Based on an analysis of curriculum materials for independent living, a set of core skills deemed important for community adjustment were identified. The core skill of "Asking for Help" was selected for Interactive Video curriculum development.

At first glance, the content focus of "Asking for Help" or "Requesting Assistance" appears relatively insignificant. However, upon further consideration one realizes that it is something we all do nearly every day, and that it is indeed something which is "smart" to do. In essence, we are all interdependent. Thus, how can we prepare mentally handicapped youth to become more interdependent? Learning when, how, and who to ask for assistance is one way.

This interactive media learning module addresses the three generic domains of when to ask for help, who to ask for help, and how to ask for help. The domains apply across the home, work, and community settings. The module consists of a 10-lesson (approximately 45 minutes each) curriculum in which simulated situations are depicted in over 50 video scenarios and 150 slides. The materials are based on the teaching technology of Direct Instruction (e.g., minimal discrimination, cumulative review, control for irrelevant variables, etc.). Finally, the curriculum is designed to be used in small groups with the assistance of the teacher.

The scope and sequence of this curriculum is presented in Figure 3. Figure 4 shows how these units of instruction incorporate video scenarios throughout the lessons. The CAVI users, with the aid of the teacher, interact with the video simulated situations by choosing among alternatives and receiving feedback on consequence(s) of selection.

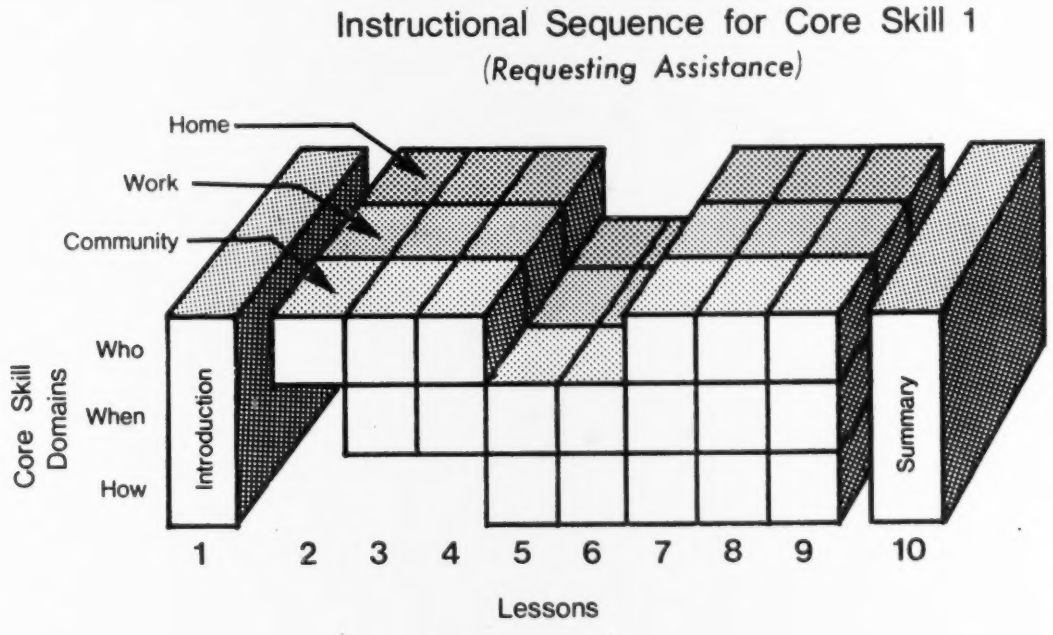

Figure 3

Scope and Sequence of Courseware

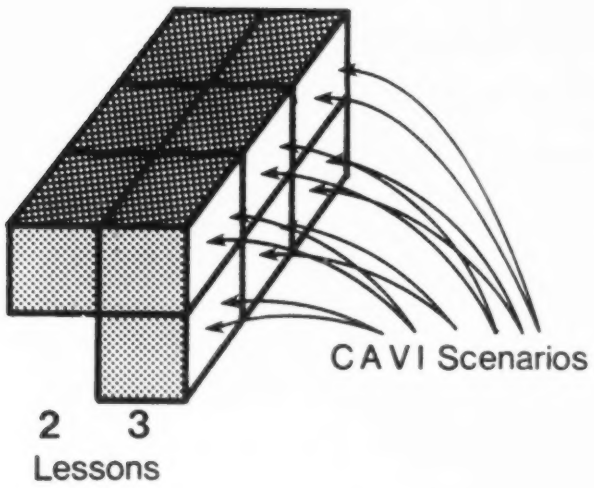

Figure 4

Goal 4: Dissemination/Utilization

The first step toward utilization will begin in the fall of 1984 with field-testing of the Asking-for-Help curriculum and its accompanying Teacher's Manual. Specifically, 10 local school districts representing secondary-level special education classes have agreed to participate in this endeavor. The outcome of this effort will be to modify and refine the Interactive Video curriculum into a final format which will be made available to interested users.

The dissemination phase of the project is an ongoing process. Of course, the opportunity to participate in a conference such as this one provides one channel for the sharing of information on this research and demonstration program.

Summary

There is no quetsion but that microcomputers have already significantly aided handicapped people. However, we have only begun to explore their full potential. One particularly promising area which needs to be examined is the use of Interactive Video with the mentally handicapped.

The University of Oregon Research and Training Center in Mental Retardation is in the second year of a five year effort to research and demonstrate Interactive Video for community adjustment training of secondary level handicapped students. This instructional technology adds to the proven benefits of CAI the capability to visually place students into different community-based situations and settings for which they are preparing.

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OVERVIEW OF THE TRI-COUNTY K-12 COMPUTER EDUCATION COURSE GOALS COLLECTION

Dick Ricketts

Since 1971 the Tri-County Goal Development Project, a consortium of public education institutions in the Portland (OR) area, has been publishing collections of course goals suitable for students in grades K-12. Thirteen collections are available: Arts, biological and physical science, business, computer education,, health, home economics, industrial arts, language arts, mathematics, music, physical education, second language, and social science. The collections provide an extensive list, or universe, of what students might be expected to learn in a the given disciplines. Each collection has several hundred goals; the computer education collection has over 800. Project personnel try to keep the collections as up to date as possible. The computer education collection, for instance, was created in 1978-1979 and has just been evaluated and revised. This edition includes goals congruent with the advanced placement computer science course.

These collections mesh with attempts by Oregon school districts to develop goal-based curricula. The Oregon State Department of Education has developed a hierarchy of state-district-program-course-instructional goals to provide a structure for a strategy of cyclic program improvement: "developing local goals, assessing student performance, identifying needs, and then using the acquired information to improve programs."(1) The introduction to the state goals sets the tone:

> "Conceived and endorsed by Oregon citizens, the statewide goals are designed to assure that every student in the elementary and secondary schools shall have the opportunity to learn to function effectively in six life roles: INDIVIDUAL, LEARNER, PRODUCER, CITIZEN, CONSUMER, and FAMILY MEMBER.... The statewide goals shall be implemented through the district, program and course goals of each local school district."(2)

The six state goals are general. For example: Every student shall have the opportunity as a learner "to develop the basic skills of reading, writing, computing, spelling, speaking, listening, and problem-solving; and to develop a positive attitude toward learning as a lifelong endeavor."(3) Each succeeding goal level in the hierarchy becomes narrower in scope and more detailed. Figure 1 shows the placement of the collections within the hierarchy, and figure 2 is a sample page from the computer education collection.

Figure 1

PLANNING

System Goal:	Students will know and be able to apply computers in a fashion appropriate to their present and future personal, career, or educational needs.
Program Goal:	The student knows principles, procedures, and limitations of computer systems and can use computers as a tool for inquiry, problem-solving, and recreation.
Course Goal:	The student knows the difference between system commands and program language statements.
Instructional Goal:	The student knows that LIST, RUN, SAVE, and DELETE are system commands in the BASIC language.

To be found in the course goal collections

MEASUREMENT

Behavioral Objective:	Given the list of words LIST, RUN, SAVE, DELETE, GOTO, END, READ, and REM mixed together, the student will identify the first four as system commands in the BASIC language.
Performance Objective:	Given the list of words LIST, RUN, SAVE, DELETE, GOTO, END, READ, and REM mixed together, the student will identify the first four as system commands with 100% accuracy.

Not integral part of Tri-County Project System of Goal-Based Planning

Note: At the classroom teacher level, course goals must undergo a final translation into instructional goals and learning experiences. The Goal Development Project has chosen not to extend into this level of planning detail.

7. Computer software
7.2 Programming techniques
7.2.1 General programming information

COURSE GOALS	Level D/P/I/U/H	Knowledge, Process or Value Classification (See Yellow Section)	Subject Area Program Goals (See Blue Sec.)	Career Ed. Program Goals (See Green Sec.)	Other Related Content Taxonomy Headings	(C) Concept/ (V) Value Words
7.2.1.7 Documentation						
1. The student knows functions of documentation (e.g., assist in correcting errors, analyze an algorithm, modify a program, inform user of program capabilities and running procedures).	I U H	K7	3 4			(C) Documentation
2. The student knows varieties of internal and external documentation.	I U H	K2 K5	3			(C) Documentation
3. The student is able to provide documentation to facilitate the modification of programs (e.g., comments within the program, program and system flowcharts, variable definition tables, descriptive text).	I U H	P66	3 7			
4. The student is able to provide documentation to facilitate use of a program (e.g., "help" commands, user's manual).	I U H	P66	3 7			
5. The student knows the importance of adequately prepared internal and external documentation.	I U H	K9	3 8 11		1.2.2	(V) Utility (C) Documentation
6. The student is able to make use of documentation when operating computing equipment.	P I U H	P23 P41	3 7			

112

The computer software section is one of twelve in the collection. The first three sections are Values and Computer Education, Processes of Inquiry and Problem Solving, and Basic Education and Computer Education. Goals in these sections often address concerns that cut across subject areas, so other Tri-County collections have similar sections. Their presence may encourage curriculum development committees to incorporate goals that may be nobody's business because they are everybody's business. The next two sections are Computer Systems, which treats computers holistically, and Calculators, which are treated as special-purpose computers. Sections 6-11 are Computer Hardware, Computer Software, Computer Applications (graphics, simulations, telecommunications, etc.), Computer Uses and Their Effects, History of Computer Development, and Computer Science. Computer Education and Careers is the last section. Because career preparation is an aspect of many secondary courses, other Tri-County collections have similar sections.

All Tri-County course goals begin "The student knows," "The student is able," or "The student values." These stems allow some correlation with taxonomies such as Bloom's. Section 1.2.2, "Computers and society: related values", has typical values goals. An example is "The student values contributions of computers to both social change and social stability." Although students often will have a favorable attitude toward the goal's topic, "Values" here does not necessarily mean "approve." Rather, it should carry connotations of "has evaluated" and "has reached a reasoned conclusion about."

Goals within a section are in not in a scope-and-sequence order. This is in harmony with the collections' purpose as a resource rather than a prescription.

Entries in the"Level D/P/I/U/H" are judgments about at what stages students would be learning material related to the goal. Not all goals have an "H" level. The goal "The student knows that computer systems can produce music and speech" has levels "PIU." This does not mean that there is nothing more to learn related to this goal after students enter high school, but that curriculum developers can expect students entering high school to have attained this goal. The Tri-County universe of course goals is bounded by kindergarten and by high school graduation.

The knowledge, process, and values categories roughly refer to what one can know about, do about or with, or feel about a set of objects. "K7" refers to learning about "Operations, Methods of Dealing with, Functions." "P66" refers to "Encoding verbal and nonverbal symbols prior to communication." "The student values contributions of computers to both social change and social stability" carries a "V2," which refers to 52 terms grouped under "Society and Culture: Related Values." The terms include justice, voting, privacy, mores, etc.

The Tri-County collections include program goals, which are one step more general than course goals. Every goal in every

collection is related to one or more program goals. Appendix A lists the computer education collection program goals.

Career education program goals are listed when a connection between then and a course goal is clear. For example, the course goal "The student knows examples of new or recent applications of computer telecommunications developed for private and/or household use..." is connected with the career education program goal "The student knows the relationship of the life role of worker to other life roles of citizen, user of leisure time, and family member." Incidentally, the career education program goals are the same for all Tri-County collections.

The concept and value words provide another way for curriculum workers to uncover themes found in the collection. Since all the collections are in a computer data base, it is possible for one to enter a word such as "utility" and retrieve all goals related to that keyword. One could also enter "K7","P66," etc. Such capabilities may help overcome the nagging transfer of learning problem.

....

Districts throughout the United States have bought the Tri-County collections, primarily as a curriculum resource. It is much easier to select goals from a collection than it is to write a set of them, and inspecting a collection helps ensure that the curriculum does not have unintended gaps. However, the collections must be understood before they can be used well. Many teachers express dismay when they first see a collection. Teachers often are more used to seeing objectives, and the sheer number of goals is disconcerting. (It may not help much to realize that facing a collection based on objectives would be something more than disconcerting.) A collection should be used only after the user reads the introduction carefully and goes through the collection enough to understand its scope and organization.

The collections have more current uses than curriculum construction and modification:

1. To coordinate curricula. Several school districts around Portland are matching their mathematics goals to the mathematics collection. When they have done this, they will be able to share ideas and resources more efficiently.

2. Test construction. Test items tied to goals have been entered in the computer data base. The Centennial School District routinely makes use of this feature.

3. Film distribution. Films in the Multnomah County Education Service District film library are tied to the collection. This facilitates ordering the right film for the right purposes.

Other uses are possible. For example, resource units could be tied to goals, films, and test items in the data base. Doing so would make it easier to relate units and to revise units automatically as films, test items, etc. are added, deleted, or modified. It even may become practical to have the computer suggest resouces and activities after processing computer-managed instruction information. The problem of computerizing resource units themselves has been solved. The University of New York at Buffalo has been doing it for precollege teachers for almost 20 years, most recently on Apples. What the university has not done is place these units within a coherent framework.

This project, the Tri-County project, and other attempts to systematize aspects of curriculum have two defects. Individually, none have the resources necessary to reach their potentials. Collectively, they have much more duplication of effort than is necessary for inservicing teachers or for adapting curricula to particular situations. Some day it will be possible to integrate these efforts in a way that the cost of coordination is less than the cost of duplicating isolated efforts. Lawyers and particularly doctors are working toward similar days, and so should educators. The resulting problems and concerns will certainly not be any worse than we face now, and the benefits will be incalculable.

FOOTNOTES

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3. Ibid. Page 7.

4. Harnack, Robert S., "Computer Based Resource Units", Educational Leadership, December, 1965. Pages 239-245.

APPENDIX

COMPUTER EDUCATION COLLECTION PROGRAM GOALS

1. The student knows events that have influenced or may influence computer development and use.

2. The student relates knowledge about computers to career goals and plans.

3. The student knows characteristics of computer-related hardware, software, and documentation, and principles underlying their design and use.

4. The student knows theoretical aspects of computer science appropriate to the student's level of computer use.

5. The student knows applications and uses of computers.

6. The student knows effects of computers on society.

7. The student knows principles, procedures and limitations of computer systems and can use computers as a tool for inquiry, problem-solving, and recreation.

8. The student values aesthetic components of computer science and computer applications.

9. The student is confident of the right to develop, hold, or express conventional or unusual ideas related to computers and computer applications.

10. The student is able to adapt concepts and processes of computer science to examine issues, to clarify personal values, to solve personal and social problems, and to satisfy personal values.

11. The student knows and values ethical obligations and legal responsibilities related to computer use.

12. The student values knowledge and skills related to computing which enable individuals and groups to cope with the complexity of human society.

13. The student is able to make responsible decisions about computer uses that affect the student's economic, political, physical or social environment.

EQUITY ISSUES IN COMPUTER USE

Sharon Franklin

Editor, The Computing Teacher
The International Council for Computers in Education
University of Oregon
1787 Agate St.
Eugene, Oregon 97403

In defining the term "computer equity", two aspects of use are usually identified. "Achieving Equity" (Edwards, 1984)[1] refers to quantitative and qualitative aspects of use. The issue of access is paramount--who uses computers and how they are used. Does the distribution, growth and use of computers in schools favor particular groups within society?

As technology advances at such a rapid pace, concern in expressed that the computer may become a powerful wedge between the "haves" and the "have nots" (Nathan, 1983).[2] Edwards points out that the new "have nots" will be the same old "have nots"--minorities, women, the poor and the disabled.

There is also growing concern that this may result in a "vast number of adults and near-adults whose ignorance of this technology may vitally affect their lives and livelihoods. This ignorance of those who cannot afford, or simply do not have, access to computer education will be a handicap in entering the job market, a handicap in making decisions about vocational education, a handicap in dealing with their children and with their children's learning" (Stone, 1984).[1]

The irony, of course, is that the computer is intrinsically fair, impartial and non-discriminatory.

> It does not pass judgment on its users; it does not select those who instruct and learn from it; its language is symbolic; and it is not culturally or sex biased. It provides an opportunity for overcoming any unfair practices to interested users; yet as used in many schools, the computer is the object of selected access that favors some populations at the expense of others (Schubert and Bakke, 1984).[1]

Anderson, Welch and Harris (1984)[1] summarize the implications in this way:

> If computer literacy is a worthy goal for all students, then there is a corresponding responsibility to formulate the means by which it can be attained. If computer literacy is not for everyone, then the grounds upon which students are to be chosen for computer training should be determined. The consequences of such decisions should be carefully considered.

I have chosen to examine three facets of computer equity which relate specifically to students:

Inequity and Economics

Research is available indicating the relationship between wealth and computer use. The relationship between the poor and minorities is well established and is considered here also. A number of interesting and quite different programs have been developed and funded by school districts and grants to address this issue.

Inequity and Gender

Research studies, surveys and anecdotal material highlight the major issues of gender and computer use. Organizations, within the larger context of sex equity, have focused on computer equity. Pilot programs, projects and research now in progress will provide additional information and resources.

Inequity and Disabilities

There are a number of individuals, groups and publications that identify sources of computer hardware and software, help identify key issues and provide a needed network for sharing information. Although little systematic, equity-related research was found, the issue of the use of computers by disabled students is nevertheless clearly an equity issue and should be seen as such.

RESEARCH AND OTHER EVIDENCE

Research on computer equity is still in its infancy. It will undoubtedly be the topic of much study in the future. Two major surveys are available: Anderson, Welch and Harris (1983) conducted a survey under the auspices of the National Science Foundation based on data from the National Assessment of Educational Progress (NAEP).[3] The Johns Hopkins University Center for Social Organization of Schools also conducted a National Institute of Education survey for the 1982-83 school year.[4] Further evidence is gleaned from other research studies, informal surveys and anecdotal material.

Inequity and Economics

-The 12,000 wealthiest schools are four times as likely to have microcomputers as are the 12,000 poorest schools. The number of students taking computer programming was much lower in schools that qualified for Title I assistance, and evidence suggests that the gap is widening. (Anderson, Welch and Harris, 1984).[1]

-Less than 17 percent of junior high students from rural and ghetto areas reported having used a computer or computer terminal in their schools, while 32 percent of students in "urban rich" areas said they had (Hueftle, Rakow and Welch, 1983).[5]

-Programming enrollments reveal a growing inequity, with sharp growth reported in suburbs and small cities as compared with little growth in big, inner cities and rural areas (Anderson, Welch and Harris, 1984).[1]

-Regional comparisons show that students living in the South, especially junior high students, are less likely to have used computers (12 percent of students in the South as compared with 24 percent in the West) (Anderson, Welch and Harris, 1984).[1]

-The Johns Hopkins study reports that while nearly 90 percent of all public secondary schools have at least one microcomputer, less than 65 percent of secondary schools with predominately minority populations and/or low socio-economic status have them.[4]

Inequity and Gender

-There is a substantial difference in males and females signing up for programming classes. In 1982, there was a difference of 8 percent females and 14 percent males--a trend which has remained constant since 1978.[3]

-Differences in access to computers outside of school have been reported. In a 1982 survey, even in high income districts, twice as many boys (15 percent) as girls (7.5 percent) reported having a computer at home (Lockheed and Frakt, 1984).[1] Miura and Hess (1984)[1] report a three to one ratio (74 percent boys to 26 percent girls) enrolled in computer camps, with 98 percent of the students middle and upper income and the ethnic breakdown as follows: Caucasian - 91 percent; Asian - 5 percent; Black - 2.5 percent; Hispanic - 1 percent; and Native American - 0.5 percent.

-Girls often report computer courses to be unstimulating, uninteresting and irrelevant. The majority of girls in a required computer course (52 percent) indicated interest in word processing and business/research applications; the majority of boys (59.4 percent) indicated interest in further training in programming languages (Lockheed and Frakt, 1984).[1]

-Much of the software currently available has themes, images, symbols or a style clearly of greater interest to boys (Fisher, 1984).[1] When 157 middle school students and 30 adults enrolled in computer classes rated software for gender orientation, the students generally agreed that nearly 40 percent of the software appealed primarily to males, only 15 percent to females, and the rest to both (Sanders, 1984).[1]

-A recent research study from British Columbia, Canada, measured 3,000 grade 8 and grade 12 students' attitudes toward computers. They found that "girls in both grades strongly agree with all statements about females in the abstract being as competent as men. However, as soon as females are asked to assess their own personal competency and self-confidence, they shift in their attitudes. The typical girl feels that women in general are capable, but that she as an individual is not competent or likely to be a computer user. The articulation of the "We can, but I can't paradox for adolescent females could possibly...describe a pervasive dilemma facing contemporary young women in many areas beside computer work" (Collis, 1984).[6]

Inequity and Disabilities

The following represents just a small sample of uses of the computer with disabled students (Hannaford, 1983).[8]

- -Microcomputers make it possible for individuals with vision defects to be presented educational material in larger print than would have ordinarily been feasible.
- -Speech synthesizers and speech digitizers are enabling those with severe communication problems to communicate with those around them.
- -Portable telecommunications devices for the deaf are helping the deaf to maintain more normal contact with the hearing world.
- -Microcomputers linked to various databases and libraries are enabling handicapped individuals who may not be able to leave their residence to obtain and communicate information.
- -Some handicapped persons are using light pointers and laser devices to input information to microcomputers which, in turn, communicate with the non-handicapped.

Federal and State Legislation

There is an awareness of the problem in Congress. The "Computer Literacy Act of 1983" (Wirth, Dem.-Colorado) and the "Computer Education Assistance Act" (Lautenberg, Dem.-New Jersey) are both attempts to provide federal funding for school districts on the basis of need for computer education programs.

A recent survey (The Southeastern Regional Council for Educational Improvement, 1983)[7] shows that all fifty states now have, or have proposed, legislation about computer use. Many contain mandates tied to equity issues.

State education departments in New York and California have begun to include screening for sexism, racism and other forms of bias in their review of educational software.

WHAT CAN BE DONE? - PROMOTING EQUITY

The problem of computer equity is difficult and will not be solved by an individual or small group. The student, classroom teacher, administrator, vendor, researcher, parent and government leader each has--like The Blind Men and the Elephant fable--a piece of the puzzle and a special part to play in effecting change.

Here are a variety of suggestions. Some can be implemented immediately; others take more time, energy, people and money--and may imply the nudging of well-established institutions. The suggestions are categorized according to the three aspects of computer equity that have been discussed; however, an overlap exists among many of them.

Promoting Economic Equity

-Help design a cooperative school-home program. It might include evening or Saturday classes for families, and a discussion of equity issues. Share information about high quality and school-compatible software. Designate some computers for checkout on weekends, evenings and school holidays.

-Negotiate with hardware vendors to give parents the same discount they give schools or educators; or, for a specific number of computers sold to parents, have vendors agree to donate one system to a less wealthy school in the district or for parents to check out.

-Keep informed about equity-related bills pending in Congress or at the state or provincial level. Write your representatives.

-Encourage the development of computer applications in all subject areas. Such development and applications of the computer will be far more interesting and diverse if they come from varied fields, rather than just one. Notice how students use computers in your school. Are all students learning to use the computer in a variety of ways in a number of different subject areas? Research results have noted that often poor, minority students use the computer only for CAI drills, while more affluent, white students learn to "tell the computer what to do" through programming and other more creative, open-ended learning activities.

-If limited access to computers is a direct result of too few computers, help plan a school-wide fundraising project to purchase additional computers.

Promoting Sex Equity

-Evaluate software in light of equity issues. Add specific equity-related items to your school or district software evaluation form (Rose, 1984).[1] When software is rejected on the basis of those items, write to the vendor and explain your reasons for rejecting the package for purchase.

-If you teach computer courses, review your lesson plans, visuals and software for bias. Invite females and males representing a variety of ethnic groups and perhaps speakers with specific disabilities to talk about how they use computers in their work. Include speakers from the arts, music, dance, writing, and sports as well as math, science, computer science and technology-related fields.

-If your district offers a computer camp, make sure there are scholarships available for less affluent students, that girls are encouraged to attend, and that students with disabilities are not denied admission on that basis.

-Be aware of who uses the computer center in your school. Help dispel the notion that such centers are male turf. If girls' access to computers is a problem in your school, try instituting "girl days" and "boy days" in the center and enforce it. Informal feedback from some educators indicates that, while such an arrangement was necessary in the beginning, it becomes less necessary each year thereafter.

-Provide opportunities for students to evaluate computer advertisements and software for bias. Have them discuss their findings and make recommendations.

-Talk with colleagues about the issue of girls, mathematics and computers. Some people suggest encouraging girls to take programming classes by limiting the emphasis on math in the beginning; others suggest encouraging a stronger link between secondary computer and mathematics courses by having all students continue mathematics learning throughout high school, joined with computer literacy or computer science courses geared to the level and capacity of each student (Lipkin, 1984).[1]

Promoting Equity with Disabled Students

-Placement of the computer is important. For students in wheelchairs, the computer needs to be on an adjustable table. For other students, such as cerebral palsied children with little motor control but good upper body control, the computer might be placed on the floor. Students unable to concentrate in a noisy computer center might benefit from a computer that is located in a more contained, quiet environment.

-A student with impaired manual dexterity can be encouraged and helped to develop effective keyboarding techniques geared to his or her abilities. A "buddie" can also help such students.

-Many of the more practical and inexpensive innovations for disabled people are the result of an imaginative person (with a little knowledge of electronics) observing or listening to the needs of a particular individual and adapting a product that is currently available to that user's needs.

-Software can be selected and/or modified for specific learning difficulties.

-For visually impaired students, braille keyboards, visual output devices, voice output devices, special software and braillers are available (Krolick,1984).[1]

-Find out about groups and publications which have information to share.

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FORGET THE STUDENTS, WHAT CAN COMPUTERS DO FOR *ME*?

Richard C. Adams

My title sounds cruel, callous, and not what the *professional educator* would think about. I know that we all have our "nice self" that thinks always of others, never goes above 55 mph inside the school district, and would never think of putting *ourselves* before our students.

But let's face it - those students are learning about the computers in primary school, elementary, junior high and right there in your high school. You know that there are students in your own classroom who know much more about computers than you ever will, because they are learning this "foreign language" as children.

On the other hand, you ARE an adult, and you ARE a good teacher. Poor teachers wouldn't be at this conference and wouldn't be concerned about the problem at all. What computers can do for you is to allow you to become *better* at what you do now.

Computers will NOT replace you as a teacher, unless you are the type of teacher who does things so mechanically, with so little imagination, and with so little humanity now that a *computer* could do everything better. A computer can help you in the classroom by allowing a machine to do the things of your job that ARE mechanical and do not use your special skills as a human being.

Does it take a highly educated professional to fill out all the adminstrative forms that get sent to you? Does it take a special person to make up worksheets for math problems? Did you go to college for a minimum of five years so that you could add up grades and get an average? Do you find it frustrating to try and make your point about budgets, grade point changes, or test scores using just logic? Do changes in the schedule by administrative fiat ruin your lesson plans wholesale?

No, the computer can't help you with everything. For example, there still has not been a feasible way for an Apple or even an IBM computer to take over bathroom patrol or engage properly in faculty room gossip. What it *can* do is to make your life just a little easier and to allow you to concentrate on those things a *good teacher* can do.

Conquering Administrivia

Administrivia is that conglomeration of papers you have to fill out so that the administrators can have a lot of paperwork to justify their own job. You know that they are trying to get students educated too, but they really feel the need for their staff to give them data with which to work. They never really get to see the students and so depend on you to give them something usable. On the other hand, most teachers would be happy if the administrators just signed purchase orders and intercepted some of the flack from parents.

There is least one method to fight back against this increasing load of things that take time away from your teaching. You may have heard of the old aphorism of computer lore that says "Garbage In, Garbage Out." That's supposed to mean that if you use faulty data in a wonderful computer program, your program will give you faulty results back.

I propose a new "old adage". When you get these incessant forms from the front office in your mailbox to fill out, let the administration become aware that with you, it will be "Garbage In, TONNAGE Back". Make sure that they find out that giving you one sheet of paper will result in their being inundated with dozens of seemingly realistic responses to their form.

How do you do this sort of thing?

The secret is a *Word Processor*.

You may have heard something about this from the Business Education Department and think that it's just a fancy way of naming their typing courses to sound more important. It isn't. Word processing might be more suitably be called "Word Manipulating".

Most of you already know how to operate a typewriter. How could you have gotten through all those education courses that required endless papers unless you did or paid out a lot for typing services? What a word processing program on a computer does is to allow you to seem better than you are.

You can quickly type all sorts of things on the typewriter keyboard, making mistakes frequently, and then *go back and make it look perfect.* You can have a "Spelling Checker" computer program look at all the words you used and note which ones it thinks are misspelled. You

can go back and move whole paragraphs to different places and put them in the order that looks best on *second* consideration. If you needed three pages of typing but it only came out to be two and a half, you can tell the computer to reformat the paper so that there are just five spaces fewer per line and print it again. You can combine older things you typed in with new letters. You can take an old letter or paper and just change a few things to fit the current circumstances.

For our purposes, you can do a dynamite response to the current request for verbiage by the office, and then *load in general stuff from all your previously typed works!*

If the memo from the office wants to know what your classroom is doing to promote National Trivia Week, you can write a short response, and then link it to your previous report on Classroom Management, and then the one you did on the Use of Visual Materials in a Classroom Setting, and then the one on how much Extra-Curricular Activities Detract from the Classroom Environment, and then throw in the one about how much your classroom needs to be refurbished, and then the little thing you wrote about Community Relations as an Aid to Pupil Communications. You can probably link these papers to almost everything you send back into the office and come up with page after page of neatly typed, well-worded responses that actually have little to do with the subject. Don't feel guilty about it. Your good words bear repeating anyway and the stuff you get from the office rarely has anything to do with good teaching so it's only fair.

As you do more memos, your library of paper on disk will accumulate and the responses will get more massive. Even administrators can learn from this type of conditioned response situation.

Of course, a word processing program allows you type at a speed closer to your thinking and to still have a finished product that says more of what you really wanted to say. This helps you to have more meaningful things to send into the office, to parents, and to your colleagues anyway. I say that it increases your typing speed because *you don't have to worry about making a mistake.* You can just type freely, concentrating on getting your thoughts down without caring if your spelling is Medieval and your choice of words perhaps not the best. You can always go back and fiddle with the details later.

The point of the whole thing is that you can put yourself back on an equal footing with the front office. After all, the principal has a secretary to do his typing

and editing, and nothing sparks production on written work so much as having a secretary to keep busy. Now you can have your own method of putting out high quality written communication in large tonnages and demonstrate to the front office why you don't want to be bothered with all their stuff in your mailbox.

Outwitting Students in Testing

Have you ever handed out a test that used an old ditto and the kids were sitting there coping with eyestrain trying to see faint purple marks on a dull gray sheet and the only thing they really got out of it was the neat smell of the freshly made copy (don't all your students sniff new dittos, for some reason?) If you type up the papers and tests on your word processor, you gain two advantages: you can always make any number of new dittos as needed, and secondly, you can easily *change* these thing from year to year as you think of something better.

Do you make 150 copies of a test after you've gotten a good ditto typed up because you know that the ditto master won't work anywhere near as well next year after it has been drying out over the summer? Does this tempt some members of your classes to go through your files? Keep your tests on disk and you can turn out a fresh ditto *whenever you want* and even come up with a new version every time!

For my Physics classes, I make each test a gruesome collection of terrible things happening to my students. James Foster may be encased in a giant block of cheese slowly moving down to the gargantuan fondue pot (figure out coefficient of friction and terminal velocity at the bottom of the ramp); Vale Hartley is re-enacting the Pit and the Pendulum with a 12 meter pendulum and a calculator to figure out how long she has to wait; George Smith is involved in an interplanetary wrestling match on one of Saturn's moons Titan and jumps straight up after someone throws frozen ammonia on the wrestling mat (figure our how high he jumps in that gravity); and the like. Each year, I just use the "global search and replace" capability of my word processor to change the names and numbers.

What if you have students in your classes who sometimes might just perhaps occasionally think of possibly looking at their neighbor's paper during an exam. A rather simple program, not even using a full word processor, could put questions in a random order, say 10 times to make 10 versions of a test. Or, for something involving calculation, a simple program could randomly print out *thirty different tests* with answer sheets for each one.

Entrenching Yourself with the Budgeteers

O.K., so you're getting the idea that computers can be of some use to you, if for nothing else more than word processing. How do you get a computer available for your own use? Each year you have to make up a budget for what you'd like to spend in the next year. The usual practice is that you spend hours trying to figure out what you'll need in a quickly-changing environment over a year away, justify each purchase over 35 cents with at least a paragraph of well-worded prose, and then the principal comes back and says "Cut your budget by 35%". Does the principal give you a well-worded paragraph for each item he wants to cut? Not usually. Instead, you have to go back and do the whole thing over again.

Setting up the whole budget on your word processor can give you a format with many justifications already written down for use in the next years as individual items keep getting cut or need annual replacement. You try and put them in the next year or the year after. Or, you could use a "spreadsheet" program with automatic addition and totalling to make the calculations at the end very fast. The computer can make changes almost painless (except for not getting the things that you need).

The part of your strategy is that you show the principal and the budget committee how you do all this and can come up with a revised budget within ten minutes and they will be envious. The more they see the value of computers to themselves, the easier it will be to get more computers available for yourself.

Getting the Computers away from the Math Department

Historically, computers in the schools, from universities to high schools, came into the math departments first. The problem was that many of the early applications required a fair knowledge of at least algebra, and those people were the most comfortable with it.

Now, however, things are much different. Yes, the computer can still be used in the math department. They do really neat things like showing graphs of equations quickly and letting kids get a feel for how equations really work and change, without all the time, chalk dust, and frustration of plotting points endlessly. They can do so many things with them that the math people may feel quite protective of their "traditions" and it may be hard to get

the computers out of their classroooms for any other purpose.

On the other hand, the science department can also use the computers as laboratory instruments, laboratory simulators, data manipulators, or for tutorial programs and testing.

Social studies can use the power of the computer to conduct simulations of battles, political campaigns, or economic events.

The English department can start having their students write their papers and essays using the same word processors for editing, rewriting, and correcting that the teachers use. The journalism and yearbook classes can use word processors for doing their layouts and get done in much less time. Teachers can use programs in grammar, spelling, and character analysis to tutor the students who need extra help.

Special education has many programs available for their use and even shop classes are finding applications with computer-aided drafting and blueprint work.

The art classes have seen a whole new field open up with animation of drawings and easy color changes.

With all these classes using computers, the math department will be hard put to justify keeping them with their classes all day. You may find, as we did, that having the computers on carts to go around the whole school is the most reasonable approach to full utilization of a small number of machines.

Getting Grassroot Support from the Rest of the Faculty

The first thing you can do is to show them all the things they can do with the computer in their classrooms, such as the ones I have listed above.

Secondly, you can take them aside and tell them all the sneaky really neat tricks you can pull to make life easier and more productive using things I told you about at the first.

In addition there are programs that allow you to type Form Letters. I'm not talking about those Christmas form letters you get from your sister Frieda where her husband John has just taken over another department, their daughter Perfection has just had her fourth adorable genius baby and

their son, the doctor, just got another award so eat-your-heart-out, you slob. Now programs exist so that you can send a letter home to parents about how their child is doing, and the letter will use the parents' names, the student's name throughout, use "he", "him", and "son" OR "she", "her", and "daughter" instead of all those strained "s/he" words, and will report specific scores and comments for each student. This takes about as much work as to write two individual letters, yet you get good communication with twenty-five sets of parents. This is the sort of thing you'd LIKE to do, but may have found your "spare" time filled with other non-essentials, such as family life, eating, and sleeping.

A "Data Base" is a like an automated filing cabinet. You use it as you would a card file for storing things. For example, you could use it to store an inventory of all the things in your classroom, writing down how many, how much they cost, the replacement cost, where they are stored, and what lessons they are used in. This could then be alphabetized and printed out as your inventory at the end of the year. In addition, it is easily changed during the year as you add, delete, or change the number of things. However, you could also "alphabetize" your inventory by the cost of replacement and have it printed out by your most expensive items first. Or, you could tell the computer to print out only those items that are used in lesson 15 and where they are to be found. Or you could have the data base print out everything that should be in cabinet IIIc. You could even use a data base as a note pad, jotting down ideas on different subjects as they came to you over two or three weeks, keying them to some particular idea, and then print out only those things that dealt with "class structure" for instance, to be later arranged into an article or another paper to send to the principal.

Then there are the numerous grading programs available that allow you to keep your grade book on disk, update it and change it easily, and then get your grades averaged, scored, and printed out with the students' names in just a few minutes.

There are scheduling programs that will allow you to put in your planned activities for nine weeks or so, and still make easy adjustments for when half your class is gone for a sports event, shoving everything over by a day, but skipping over weekends or special days. You can get a new print out of the whole schedule, newly revised, for your own use or to hand out to the students, in under four minutes.

Salary schedule disks can be used by anyone on a negotiating committee to make up a new proposal for the

school board in under four minutes, and be able to figure out almost a dozen different types of schedules, with total cost.

Fancy graphing programs can present a chart of how your budget or salary has not even kept up with inflation for the last five years, how students did on standardized tests compared to last time or to the national groups, or any number of things. You can get column charts, pie charts, bar charts, line charts, or anything you need to sell you point.

Do all these things make you teach better? Probably not. On the other hand, they will ALLOW you to teach better by taking care of all those little things that take up your time doing things not really involved with teaching at all.

Don't let the students be the only ones to benefit from the high tech revolution!

Richard C. Adams
Pleasant Hill High School
36386 Highway 58
Pleasant Hill, OR 97455

NOTE: in the presentation at the conference, I will be showing attendees examples of the programs above and will have some public domain programs available for Apple computers for those who bring blank disks for copying.

INTERACTIVE VIDEO IN EDUCATION

Ron Thorkildsen

Utah State University

The first videodisc player and production facility became available in limited supply in 1978. Immediately it was heralded by instructional designers as the omnibus machine and a medium without constraint (DeBloois, 1979). It is interesting to note that a manual on programming the videodisc was developed three years before the first prototype became available (Bennion, 1976). However, even with this advanced planning and heralded arrival, the videodisc has not been an overwhelming instructional force. The past three years have shown a notable increase in the use of the videodisc in military, industrial and medical training, but there are only limited instances of the videodisc being used in the educational system. Does this mean that the original prognosticators were wrong? Not at all, their visions were merely early. There are a number of reasons for the delay and most are closely interrelated. However, two reasons stand out: the educational community is traditionally slow to change and videodisc production is very expensive. These reasons seem obvious and somewhat mundane; dealing with the first is a fruitless and futile endeavor, but the second may have important instructional ramifications.

It seems paradoxical to suggest that the high cost of using this medium has both delayed its use and increased its value to education. The paradox weakens under the hypothesis that videodisc production is too expensive to use for poorly designed instruction. Consequently, the videodisc may have been spared from the plethora of poor instruction so prevalent with microcomputer instructional software. It is logical, but not empirically supported, that videodisc developers will expend more time in serious planning before producing a product which is expensive to produce and cannot be changed once produced. Additionally, recent advances in the subfield of Artificial Intelligence, Intelligent Tutoring, has resulted in software that could be combined with the videodisc to produce a powerful intelligent tutoring system.

A number of videodiscs for education and training have been produced, but few research studies have been conducted. Empirical evidence of the effectiveness of videodisc-based instruction is rare; however, there have been sufficient projects and related testimonials to continue to embrace the potential of the videodisc in education. It is the purpose of this paper to elaborate on this potential by describing the videodisc's capabilities, reporting on various videodisc projects, and discussing the possible relationship of interactive video and a subfield of artificial intelligence—intelligent tutoring.

Videodisc Technology

Videodisc technology consists of the videodisc, the videodisc player, and the equipment necessary to produce the

videodisc.

The videodisc provides for a high volume of storage of both audio and video information. It is capable of storing 54,000 individual frames per side. Each frame can contain a single picture, such as a 35mm slide image. When the single frames are played at 30 frames per second, each side of the disc contains 30 minutes of motion. Associated with the single video track are two audio tracks. The audio tracks are independent and may be used in a variety of applications, such as recording two different languages associated with the same video. The videodisc is truely an omnibus medium; it has the capability of presenting motion film, slides, graphs, and high quality audio.

The videodisc player may be played at regular speed, in single-frame stop motion, and at various speeds of slow motion. All of these functions can be selected easily, but the most impressive feature of the videodisc is rapid random-access capabilities. It searches all 54,000 frames in approximately three seconds. In general, search times in educational applications take one to two seconds. For example, a segment of instruction can be presented, and depending on the learner's response, the videodisc can present a video and audio feedback segment appropriate to the learner's response within one second.

Two types of videodisc players are currently available, laser optics systems and capacitence systems. RCA utilizes the capacitence system. This system was designed primarily for the home entertainment market; however, RCA has recently released a system with random-access capabilities. Laser optics systems are being produced by a number of organizations including Hitachi, SONY, Thompson, Pioneer, and Magnavox. The Pioneer VP 1000 and Magnavox players are designed primarily for home entertainment use, while the Pioneer 7820, Thompson, Hitachi, and SONY are designed for educational and industrial use. Rapid random access is the primary advantage of the education/industrial models. Entertainment models sell for approximately one-third the cost of the educational/industrial models.

Controlling the Videodisc Player

There are a number of options for controlling or operating a videodisc player. They are typically referred to as levels of interactivity and are described below:

Level 1 - The videodisc player is controlled manually with a remote-control device. This device has function keys for each of the player's operations. For example, to search for a particular frame on the disc, the operator enters the frame number on the remote-control device and pushes the search key to initiate the search. After finding the desired frame, the operator has numerous options such as forward or reverse play, single-frame

display, slow-motion play or regular play with or without audio from either or both of the audio tracks. All of these functions are accessible from the remote-control device.

Level 2 - Some educational/industrial models such as the SONY and the Pioneer 7820 have built-in microprocessors. All functions mentioned above can be controlled by this microprocessor. The computer program that determines the control is stored on the videodisc and then loaded from the disc into the microprocessor. The flow of the presentation is controlled by the logic in the computer program and by input from a user with the remote-control device.

Level 3 - The videodisc player is interfaced with an external computer. The logic of the presentation is determined by the computer program in the external computer, and by input from the user, usually entered through the computer's keyboard. This is advantageous because the computer can supply text and graphics in addition to the still frames and motion supplied by the videodisc. Additionally, student progress data can be collected and stored on an external storage device such as a floppy disc. Typically, microcomputers are used as the external computer, and videodisc interfacing is now possible with all popular personal computers.

Using Videodiscs in Training

The most prevalent instructional use of videodisc technology is in industrial, military, and medical training programs. Examples of these applications follow. Educational applications, the primary emphasis of this article, are described in the next section.

Medical training. A rapidly increasing and important use of videodisc technology is medical training. Medical diagnosis is becoming increasingly visual with x-rays, photomicroscopy, and acoustic imaging which makes the visual storage capabilities of the videodisc particularly appropriate. This capability, combined with the ability to present high-quality motion sequences, makes the videodisc particularly useful in medical education. For instance, a surgical procedure can be viewed at normal speed or one frame at a time. Videodiscs have also been developed to instruct patients in the management of diabetes and to provide patient information on radiation therapy for cervical cancer.

In two projects, the mass storage capability of the videodisc has been used to produce medical reference discs. A urology disc has been developed which includes 500 color images selected from 3500 slides of x-rays and medical photographs. Another project, at the University of Washington, has produced a videodisc that contains over 6,000 slides on hematology. These slides can be readily accessed by the remote-control unit, a Level 1 application, or the disc can be used as a visual data

base in a computer-controlled instructional program (Stewart, 1983).

Industrial training. A series of 60 interactive videodisc programs on the subject of health physics is being produced for the Nuclear Energy Industry. These programs could also be used by the industrial manufacturing operations dealing with hazardous processes.

In another industrial application, a videodisc was designed as a marketing aide to supplement IBM retail store personnel and allow customers to become more familiar with IBM products.

Two of the largest industrial users of videodiscs are General Motors and Ford. Together they have installed more than 25,000 industrial videodisc players and have produced a number of videodiscs for training and customer information.

Military training. At the University of Maryland, a videodisc program has been developed to teach functional literacy to field soldiers. The videodisc program is a time-travel simulation in which the soldiers travel through historical events such as the Battle of the Bulge. The program is in a game format, and soldiers must apply functional literacy to accomplish their missions (Videodisc/Videotex, Spring, 1983).

Researchers at the University of Maryland and Utah State University collaborated to produce a training videodisc for field soldiers on electrical maintenance of tracked and non-tracked vehicles (DeBloois, 1980).

Videodisc Applications in Education

Given the capabilities of the videodisc, its potential for educational applications is unlimited. However, determining the extent to which this potential will be realized requires a commitment to continued creativity and investigation of the medium and other related technologies. The application of videodisc technology to education is in its infancy. At this early stage, each educational application must be evaluated as a unique case, with criteria for acceptability carefully matched to the educational problem being addressed. What is acceptable given the educational goals of one application may not be acceptable for another. With respect to special education, the videodisc seems even more appropriate because of the match between the capabilities of the technology and the limitations of the handicapping condition.

Special education. With the evolution of the computer, the promise of Computer-Assisted Instruction (CAI) to provide a vehicle for individualization became more and more apparent. However, a major problem exists when trying to use CAI with the mentally handicapped. Traditional (CAI) and individualized self-administered assessment instruments required the student to have

reading skills, which essentially precluded a majority of the population of handicapped students. Consequently, it is necessary to use spoken instructions to interact with the student. Until very recently the technology has not been available to do this. However, with the advent of microelectronics and laser optics, the technology is now available. Recently developed videodisc players coupled with the microcomputer provide the technology to deliver spoken instructions.

The IVSET Program. One of the few projects that did produce empirical evidence of the effectiveness of videodisc-based instruction was conducted as part of the Interactive Videodisc for Special Education Technology Program (IVSET). The major purpose of the IVSET Program was to develop and field test computer-aided instruction and assessment systems for mentally handicapped students. The resulting system is referred to as the Microcomputer/Videodisc (MCVD) system.

Students interact with the MCVD system by viewing visual material on the monitor (with associated audio). The student responds by touching the appropriate image of an object on the monitor screen. When the student touches the screen, two light beams transmitted from each axis of the touch panel are interrupted, and the point of interruption is detected by the touch panel. The X and Y coordinates are then transmitted to the computer. The computer program in the microcomputer contains the correct coordinates for each segment of instruction. The coordinates transmitted by the touch panel are compared to these correct coordinates.

On a correct response, the microcomputer responds by finding and retrieving a segment on the videodisc which contains an audio and visual positive feedback. Other possible response conditions are an incorrect response, and a non-response. Segments are present on the videodisc for these response conditions as well as a variety of feedback, including animation and motion picture sequences.

Each segment of instruction has associated parameters that specify the number of times a student must respond correctly to advance to the next instruction segment. As the student interacts with the system, data are collected by the microcomputer and stored on a floppy disc by the Apple disc drive.

Five instructional programs were developed for use with the MCVD system during the first project: (1) Time Telling, (2) Identification of Coins, (3) Functional Words, (4) Sight Reading, and (5) Directional Prepositions. Each of these programs was field tested during the course of the project, and the results of these field tests are available in the Final Report of the project (Thorkildsen, 1982).

Artificial Intelligence and the Videodisc

The study and development of expert systems is a research area in Artifical Intelligence that will be particularly important to education. As noted by Feigenbaum and McCorduck (1983), "Artificial Intelligence is emerging from the laboratory and is beginning to take its place in human affairs." (p. 1). This is most evident in the field of Expert Systems. Stefik, Aikins, Balzer, Benoit, Birnbaum, Hayes-Roth, and Sacerdoti (1983) describe this field of AI as follows:

> Expert systems are problem-solving programs that solve difficult problems requiring expertise. They are termed knowledge based because their performance depends critically on utilizing facts and heuristics used by experts. Expert systems have been used as vehicles for AI research with the rationale that they provide a forcing function for research issues in problem solving and a reality test for their workability. (p. 59-60).

When these expert systems are used in an educational context, the terms "intelligent CAI" or "intelligent tutoring systems" (ITSs) are often applied to the products. For example, a well-known expert system that led to educational applications is MYCIN (Davis, Buchanan, & Shortliffe, 1975). This program allows the user to feed in information on the characteristics of bacterial cultures and the patient's present symptoms. It then deduces the bacterial disease. In its initial form, this intelligent data base was used as a diagnostic tool by the physician. This same intelligent data base was then included in an intelligent CAI program, NEOMYCIN (Clancy & Letsinger, 1981), designed to be used to teach the diagnosis of bacterial diseases.

Intelligent tutoring systems are being developed and becoming commercially available both for main frame and microcomputers. These systems will allow instructional developers to build knowledge bases and develop intelligent tutoring systems which use these knowledge bases.

In addition to increasing the availability of high quality and direct services, AI research could improve our thinking about teaching and learning. This point was made by Sleeman and Brown (1982) in describing the development of intelligent tutoring systems (ITS). They stated that,

> Much of what constitutes domain-specific problem solving has never been articulated. It resides in the heads of tutors, getting there through experience, abstracted but not necessarily accessible in an articulatable form. Since a computer-based coach has limited opportunities to learn experientially, at least in the foreseeable future, its designers must make this knowledge explicit. Likewise in an arena of tutorial

> strategies, much remains to be discovered and made explicit. We hope that educational theorists will find the explicit formulation of tutoring, explanation and diagnostic processes inherent in intelligent tutoring systems a test bed for developing more precise theories of teaching and learning. (p. 9).

Conclusion

Combining the capability of the videodisc to store and deliver high-quality video and audio with the capabilities of intelligent tutoring systems should result in highly effective instructional systems. While costs of the various components are presently quite high, substantial cost reductions are occurring rapidly. For instance, the cost of an interactive videodisc player has gone from $2,500.00 to $900.00 in the past year. Predictions are that videodisc production costs will begin to decrease, and the costs for expert system software will decrease as it becomes available for microcomputers. In the near future, costs should no longer be an inhibiting factor. By using these combined technologies in research, we should learn a great deal more about learning and teaching. Instructional designers will have the tools to greatly enhance the design and delivery of instruction.

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COMPUTING HISTORY TO USE IN YOUR CLASSROOM

DORIS KEEFE LIDTKE

National Science Foundation

The views expressed in this paper are those of the author and do not necessarily reflect those of the National Science Foundation.

COMPUTING HISTORY IN THE CURRICULUM

Why Computing History in the Curriculum

Most experts in the field, as well as most curricula guidelines, specify that the history of computing is to be covered in introductory computing courses (Center for Learning Technologies, 2-10). Nearly all introductory texts include some history, some giving a rationale for its inclusion.

> An understanding of the evolution of data processing is especially helpful in understanding the capabilities and limitations of modern computers (Mandell, 19).

> It is exceedingly useful for students of any discipline to be familiar with the history of their field. Such an awareness helps one to understand how developments have actually evolved. It also provides insight into the impact of those developments both within the field and on society itself....Students with a sense of historical perspective are in a far better position to understand the impact of computers in a technical and social sense (Stern and Stern, 15, 17).

> I have gone briefly into the history of computers, however, partly because it is a fascinating area largely unknown to most people, but also because a knowledge of their evolution from their earliest beginnings to the present day helps one to understand the nature of their inevitable development in the future (Evans, vii-viii).

Henry May, the late professor of the history of mathematics at the University of Toronto, wrote:

> There is great interest in computers and what they can do, but also interest now in telling the story, in telling the history. This is a very happy circumstance in my opinion. It indicates the maturity and sophistication of the field. Studying the past, it seems to me, is necessary for knowing what we are doing in any given field, or for understanding what the field is about (Metropolis, Howlett and Rota, 13).

Bruce MacLennan suggests that for computer languages history is important.

> History is an important aspect of any design discipline. Often the designs used in the past can only be understood in their historical context. Also, it is important that the student be aware of the designs tried in the past and why they succeeded or failed (MacLennan,ix).

MacLennan uses history as the organizer for his book on programming languages

> The importance of historical context leads to another organizing principle, summarized as: ontogeny recapitulates phylogeny. This principle means that if the learning process in the student repeats in summary form the historical learning process in the computer science field, the student will have a firmer grasp of the subject. This does not mean that the student must be exposed to every mistake and explore every dead end in the field of programming languages; ontogeny recapitulates phylogeny, it does not duplicate it.

If the section on history occurs at the beginning of the course it may offer a skeleton upon which to build. This may make good pedegogical sense, but seems to be less motivating for the students. Most students in a computing class would rather get started using the computer than to spend time learning about the history of the computer. From the viewpoint of the teacher it seems wise to use the computer as a motivation device whenever possible. Also it seems that the sooner students begin to use the computer the more practice they can get and the more they are able to learn. Thus interleaving the history throughout the course seems a reasonable idea.

In almost any course the students can begin to use the computer the first day of the class. Students can be supplied with disks (or tapes, if need be) and learn how to load and run simple programs. Early, positive experiences with the computer seem to be important to later success.

As the course continues the history can be included with the concepts. Students can learn to input from a keyboard, with a mouse, by touching the screen, by using a lightpen or by using any available device. Once they have mastered one device, other available devices can be introduced, and those devices that are not available may be introduced via overheads, pictures, films or oral descriptions. Historic input devices should be included at this time.

Most texts include coverage of early calculating devices, some going back to the earliest ideas of counting. Many texts include a rather long section on punched cards and the early computing devices developed in the United States. There is seldom any mention of computing activities that occurred in countries other than the United States. This history of computing invariably goes on to describe the early computers, and the

first, second and third generations of computer hardware. There is not often much coverage of the history of software development except for a short discussion of the increasing costs of software. Future texts may address computer developments in other countries and put more emphasis on software development. The high costs of software will probably lead to greater emphasis in this area.

HOW TO INCORPORATE COMPUTING HISTORY

There are several ways to make history a part of an introductory course. Though some may use it as an introduction, I would recommend that it be interwoven throughout the course. Students need some background in order for the history of computing to have meaning. Students are usually eager to begin useing the computer. Another alternative is to teach the history of computing at the end of the course. There is, however, a pitfall that can occur for it is easy to run out of time and to be unable to adequately cover the history.

SAMPLE ANECDOTES AND WHERE THEY MAY BE USED

Whatever programming language becomes the language that the students will use to implement the algorithms they develop it is important that they understand that programming is not easy. It is also important that they realize that many, if not most of the programs that they write in elementary classes are not really programs which are appropriate for computer solution. Indeed, most elementary programming assignments could be better done by hand or with the aid of a calculator. Try to emphasis this to the students and show some examples of significant computer programs.

> Almost as soon as the first computers were built, it became obvious that programming was very difficult; this fact has not changed. Indeed, the tasks we have attempted to accomplish with computers have grown rapidly in ambitiousness and size. Much of the difficulty of programming stems from complexity, the necessity of dealing with details at one time. Programs may contain hundreds of thousands or even millions of lines of code. Considering these lines (together with the operators and operands that make them up) as parts that must be assembled individually to make a program work correctly leads to the conclusion that programs are some of the most complicated artifacts ever built. One of the primary tasks of programming languages is the conquest of this complexity (MacLennan, 1).

In order to give some idea of the complexity of this early programming it can be instructive to have students write some programs or subprograms to perform multiplication or to operate on floating point numbers or to handle indexing.

The earliest computers did not have built-in floating-point operations; these did not appear until the IBM 704 in 1953. On the other hand, the primary application of many of these machines was scientific and numerical computation, which requires numbers of a wide range of magnitudes. This necessitated manual scaling, a technique in which numbers were multiplied by scale factors in order to keep them within the range of the integer arithmetic facilities of the computer. This was a very complicated process requiring a detailed analysis of the algorithm. The difficulty of manual scaling led to the development of floating-point subroutines, that is, of subroutines for performing basic floating-point operations (addition, subtraction, multiplication, division, square root, etc.). Although these often slowed down a program by at least an order of magnitude, they so simplified the programming of numerical problems that they were widely used.

Another facility missing from many early computers was indexing, the ability to add a variable index quantity to a fixed address in order to address an element of an array. You are probably aware from your own programming experience that the array is one of the most common data structures; it was even more so in the scientific and numerical problems that dominated the use of early computers. Now, one of the important ideas of von Neumann, and one of the distinguishing characteristics of a von Neumann machine (which includes most computers) is that the program and data are stored in the same memory. Therefore, it is possible for a program to modify itself or another program as though it were data. Since most early computers did not have index registers or indexed addressing modes like modern computers, it was necessary to accomplish indexing through address modification. That is, the program would add the index to the address part of a data accessing instruction. Needless to say, this was an error-prone process. It also consumed much of the scarce memory with this address modification code. For this reason, it was also common to use subroutines to perform indexing (MacLennan, 3-4).

Certainly one of the most influential people in programming languages is Captain Grace Murray Hopper. It is worth noting that among her many accomplishments, she earned a Ph.D. in mathematics from Yale University in 1934. The anecdote below could be used when discussing different number bases.

In the early years of programming languages, the most frequent phrase we heard was that the only way to program a computer was in octal. Of course a few years later a few people admitted that maybe you could use assembly language. But the entire establishment was firmly convinced that the only way to write an efficient program was in octal. They totally forgot what happened to me when I joined Eckert-Mauchly. They were building BINAC, a binary

computer. We programmed it in octal. Thinking I was still a mathematician, I taught myself to add, subtract, and multiply, and even divide in octal. I was really good, until the end of the month, and then my checkbook didn't balance! It stayed out of balance for three months until I got hold of my brother who's a banker. After several evenings of work he informed me that at intervals I had subtracted in octal. And I faced the major problem of living in two different worlds. That may have been one of the things that sent me to get rid of octal as far as possible (Wexelblatt, 7).

There are several other highly useable quotes in the Keynote Address that Captain Hopper gave at the Opening Session of the ACM SIGPLAN History of Programming Languages Conference, June 1-3, 1978.

I think the first step to tell us that we could actually use a computer to write programs was Betty Holberton's 'Sort-Merge Generator.' Your fed it the specifications of the files you were operating on, and the Sort-Merge Generator produced the program to do the sorting and merging, including not only carrying out the operations, but also managing all of the input and output in the various tape units, and it contained, I think, what I would define as the first version of virtual memory in that it made use of overlays automatically without being told to by the programmer. I think that meant a great deal to me. It meant that I could do these things automatically; that you could make a computer write a program (Wexelblatt, 9).

I think I can remember sometime along in the middle of 1952 that I flatly made the alarming statement that I could make a computer do anything which I could completely define. I'm still of course involved in proving that because I'm not sure if anybody believes me yet (Wexelblatt, 9).

On page 11 of the same book Hopper relates how she came to develop the idea of subroutine handling based upon her early experiences playing basketball.

It is usually of interest to students to learn about events that are associated with their own geographic area. So the inclusion of local interest anecdotes is desireable. Naturally there are many such stories to be told about activities in the Washington, D.C. area, but every area probably has some computing history. At Towson State University I found interesting history about our own computing center, the usage of computers by the Social Security Administration, and early computing activities at Aberdeen, Ballistics Research Laboratory, where the ENIAC was from July 29, 1947 until October 2, 1955 (Goldstine, 234-5).

By 1944 requests for wholly new ballistic tables (demanding the calculation of hundreds of trajectories for each table) were pouring into Aberdeen at a rate of six a day. A skilled

person with a desk calculator could compute a single sixty - second trajectory in about twenty hours....The ENIAC, when completed, would require just half the time of the projectille's flight -- thirty seconds -- to do the calculations.

John W. Mauchly and J. Presper Eckert, Jr. of the Moore School, working with Captain Herman H. Goldstine of the U. S. Army, began planning the ENIAC in 1943, but the machine was not completed until after the war had ended. It was, however, widely used for scientific calculation until the early 1950s (Eames and Eames, 133).

CONCLUSION

The history of computing is rich with anecdotes that can add interest to the introductory courses. In recent years many books have been published in this area. If you begin now and collect a few good anecdotes each year you can use them to enrich your classes and emphasis the concepts you are teaching.

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COMPUTERS IN EDUCATION
PROGRAM DEVELOPMENT AT THE DISTRICT and ELEMENTARY SCHOOL LEVEL

by
Jack Turner, Computer Coordinator, Eugene Dist. 4-J
200 N. Monroe, Eugene, Or. 97401

> The battle for the learning place is already over, but you school folks don't realize it yet. With the coming of inexpensive microcomputers schools have lost their exclusive and traditional franchise as the learning place for young people. Your institutional momentum will probably carry through the end of this century, but thereafter the institution of public schools will be remembered as quaint -- and as far removed from the mainstream of learning -- as we now think of monasteries.

This riveting comment was spoken to me almost four years ago by a Boston colleague who does not share my faith in the institution of public schools. A very knowledgable computer thinker, he was at that time the editor of a national computers in education magazine. A large part of my surprise in hearing his prediction derived from our difference in perspective and interpretation. To me the phrase "computers in education" was synonymous with computers in SCHOOLS; to my friend the phrase knows no such institutional bounds.

It remains an open question as to whether the institution of public schools can accomodate itself productively to the recent infusion (intrusion?) of inexpensive computer power and the new potentials implied by this technology. The prediction quoted above arises from a belief that the organizational structure and the culture of public schools is so resistant to change that ultimately the computer will become neglected or trivialized within the schools and, as a consequence, the computer will take learning outside the school structure. The monastery, you may recall, held virtually exclusive franchise rights on learning and the transmission of culture until the invention of the printing press.

As the district computer coordinator for a 17,000 student school district in Eugene, Oregon, one of my chief interests is to ensure that a "monastery future" does not happen, and that our schools learn to capitalize on the new potentials afforded for computer learning. My frame of reference throughout will be the Eugene School District, but I feel confident that our local school system, if different, is so only in degree from most others across the country. The intent of this paper is to identify and comment on several key issues which I think will have a great deal to do with whether public schools will ultimately be able to incorporate a powerful electronic tool, or whether we will unwittingly trivialize the computer and perhaps be rendered obsolete by it.

*** THE IMPLANT SOLUTION The ceaseless media parade of showbusiness celebrities now hawking competing brands of computer hardware are wrong. They would have us -- both educators and the public -- believe that the key to a golden educational future is the

simple acquisition of a computer -- at least one per home and many per school. The fact is that we are already approaching that goal, at least in many school systems, but the new presence of computer hardware precipitates multiple new problems for each worthy possibility. And unless we are prepared to contemplate and then undertake some unprecedented steps in institutional patterns, beliefs, and assumptions, the flood of computers now being proudly installed in American public schools will be wasted on us.

Two examples will illustrate the case. I fear a future for students where computers are plentiful in schools, but their dominant use is as drill and practice task masters or answer givers. Yet this very application is by far the most common present use for computers in classrooms. A major reason this is so is because teachers and schools can use computers as drill masters with absolutely no modification of the present "culture" of schooling. Computer use can be timed to fit within our class period structure, the content delivered via the C.P.U. is consistent with "real school" curriculum, and this thoroughly modern classroom won`t get so cluttered up with ditto sheets because an expensive device now makes work sheet pages obsolete. In this scenario I call the computer trivialized; it fits comfortably into the existing structure and patterns of schooling, but the machine contributes little beyond a sense that the school is "up-to-date" and some new management problems for the teacher.

The second example is at once more promising but more threatening to the structure of schooling as presently constituted. My district will decide this summer how best to teach touch typing to elementary children, probably those in the last term of the 3rd grade year. In the middle of 1984 I make this statement to almost nobody`s surprise. But less than 5 years ago nobody in public education would have taken it seriously. The new presence of microcomputers is directly responsible for our design to shift touch typing forward from a high school ELECTIVE to a primary level REQUIRED.

I should add that we approach this summer`s task with trepidation. We believe it imperative that young children should learn to touch type at least as rapidly as they can write with a pencil, but once the system shift required to implement this new training is in place we don`t know where all the implications will lead. (Some of our present high school typing teachers fear that they do ....)

Apart from the belief that word processing facility will allow for better development of student`s writing skills, there are at least two other reasons militating for the early acquisition of key-boarding skills:

1. If most students remain "hunt and peckers" the near term shortage of computers in schools is exacerbated. Kids presently waste a great deal of time (both their own and the computer`s) while searching for the correct keys required to type their names.
2. One of the attractive attributes of drill and practice software is that students can use it without being able to touch type. You won`t find many examples of drill and practice programs which call for answers beyond a single keystroke entry.

It should be clear from these examples that school systems intending to incorporate computers into the fabric of learning will need to go far beyond hardware acquisition. And we`ll need to confront questions as basic as the continued value of teaching such traditional basics as arithmetic facts, and perhaps someday, spelling and grammar.

*** THE GRASS ROOTS GENESIS Among the reasons computers will be persistent but hard to "tame" in the public school environment is that of how they got here in the first place. Unlike any other educational innovation that comes to mind, computers virtually sneaked in under the edge of the tent. Rather than following the conventional -- and controllable -- top-down pattern typically found when school systems undertake a new program, computers have invaded the schools from the classroom level up. Attention from the district level has generally been after the fact.

This program innovation can truly be said to have been brought to us by the teachers -- make that some teachers -- but the contagion is spreading. The upshot of this odd genesis is that school systems now have pockets of computer activity which can be described as intense and entrepreneurial; that is, in SOME schools, at SOME grade levels and in SOME subjects. And because these pockets of activity have originated from individual teacher`s efforts, there is apt to be no common philosophy, program coherence, or focus.

From a district program development perspective the chief dilemma here is how to "bottle" the revolution, a refreshing problem but a very serious one. Its grass roots origins within the schools make computers much more likely to become a lasting innovation, yet it is a fragile process to control, align, and capitalize on the teacher-originators as program development at the district and school-wide levels reduce their perceived resources and flexibility.

*** BEYOND VOLUNTEER TRAINING At the moment the pressure for hands-on computer training among teachers is a staff developer`s dream come true. Teachers in large numbers are requesting whatever training is needed to become "computer literate"; inservice computer classes offered by districts are presently limited only by available funding, not by the expressed needs of its computer-literacy-hungered staff members.

But this apparent land rush to computer competence is masking a problem which will soon need to be confronted if school districts intend to refine computer activity in the schools into an organized computer program which has a sequence of development over a multiple-year span. What about that fairly large percentage of teachers who are not volunteering to go to computer training? It is not particularly insightful to observe that many adults are secretly hoping to either retire or die first, before the imperative for computers engulfs their particular position. But unless we leave computer competency to the entrepreneurs identified earlier, school systems will have to require reluctant staff members to become computer competent. The only other alternatives are to reorganize staffing patterns to accommodate the "computer-illiterates" or to settle for the present pockets of classroom computer activists in the system.

The former strategy is politically untenable; the latter is programatically unworkable. The only productive alternative is to identify and sequence computer program goals and activities, then provide train- ing for all staff whose students are at a given place within the program sequence.

At this juncture two alternative strategies suggest themselves as being less painful to implement. The first would designate that only computer specialists should teach about computers; each school could have one or more such specialists for all teaching related to comput- ers. This specialist concept implies that the computer is a subject to be taught (ala computer science) and a comfortably narrow subject at that. Students would be dispatched to the specialist`s room to learn about computers or learn with computers, but only for an amount of time limited by the specialist`s availability.

The second -- and more seductive -- strategy is to give all teachers the minimum computer training possible: how to teach students to turn on the machine, and to load and run programs that are presumably well done and compatible with the school's regular curriculum. That way all students would at least have more frequent access to a computer, and this activity undisputably augments the classical schooling process.

But both of the foregoing strategies trivialize the computer and its potential for interactive learning. Both would miscast the computer's highest application as subject rather than object, and as master rather than as incredibly versatile tool. If school systems are to integrate computers into their 'woodwork' and get the best possible value from the machines for all students, then we must necessarily confront the day when ALL teachers will need to be skilled in appropriate uses for the new tool relative to their disciplines.

*** THE KEYSTONE OF COMPUTER LITERACY I think we shall never hear the final definition of 'computer literacy', but there is definitely a major shift taking place regarding its keystone elemenc: program- ming skill. The rush to teach BASIC (or Pascal or whatever) has been well documented as districts and teachers design computer instruction for students. Whatever else one might include within the concept of computer literacy, programming skill has been the keystone. In my district, for example, the major effort within the required middle school computer course has been to teach elements of BASIC to all participants.

In the face of this "every student a programmer" effort comes an employment projection for the first two decades of the twenty-first century. According to the projection only 3 to 5 percent of adult workers by then will need to have programming skills to do their jobs satisfactorily. Those middle school students we are presently attempting to cram full of BASIC computer language will be among the adult workers the forecast speaks of yet only one in twenty of them will need to be a programmer to do his/her job. And it's a safe bet that BASIC will not be the language that that person will need to know.

We must shift the focus in computer literacy away from mastery of a programming language toward mastery of relevant computer applications programs and their appropriate uses. Leave programming

skills to the status of elective courses and shift any required coursework over to an applications/tool focus. I agree with a position recently taken by David Moursund, a professor of computer science at the University of Oregon. He believes that for most students the only computer "languages" they'll need to know are the special words and keystroke combinations required to skillfully interact with a useful appplications program like a word processor or spreadsheet.

*** INTEGRATING COMPUTERS INTO THE CURRICULUM To this point I have identified a series of computer-related problems and facts that would make my Boston colleague redouble his prediction for the computer-assisted demise of public schools. I have been explicit in the opinion that computers should not remain exclusively in the outposts of the teacher-entrepreneurs, and that most of the comfortable strategies for school uses of computers are short-sighted and trivial. The remainder of his paper will describe how it might be different if we can look on computers in ways other than additive.

The computer innovation will be transformed into real school only when we examine the existing curriculum with two key questions in mind:

1. WHAT DOES IT MEAN TO BE EDUCATED IN AN ENVIRONMENT WHERE COMPUTERS ARE READILY AVAILABLE?

2. HOW CAN WE ORGANIZE AND IMPLEMENT THE TASKS OF BEGINNING THE REDEFINITION?

Since becoming the computer coordinator for the Eugene School District I have been frustrated by the issues embedded in integrating computers as tools into the curriculum. I observed many teachers, read widely, and sought out presentations at computer conferences, all of which were titled "Incorporating Computers Into ...". Without exception what I found was the additive model, typically being done by heroic individual efforts within individual classrooms. The model is not institutionalized into the fabric of education because it depends on a high-energy teacher who is both capable and willing to do all the extra work involved with enriching the student's experiences in that particular classroom.

An illustrative parallel might be the overhead projector, an earlier additive innovation. In both cases the class can be conducted with or without the hardware available. If you have it the presentation will probably be enriched, but if the hardware is unavailable the class can still be conducted (and with perhaps less effort on the teacher's part.) Now substitute either text materials or writing instruments in my parallel for the overhead projector. No longer are we talking about additive technologies. If either of these tools were not available the nature of teaching/learning would be seriously transformed. I believe we must head for the situation in schools where access to a computer is as important (and "natural") as is our present acceptance of texts and pencils as being integral to learning.

The following proposal has been developed as the long term plan for integrating the computer as tool into the curriculum of the Euvene School District. It is the first major step on a path that has consequences we cannot yet anticipate.

PROPOSED PLAN FOR INCORPORATING COMPUTERS INTO THE CURRICULUM

It is clear that to educate students without reference to computers would be a disservice. It is also clear that simply adding computer courses or supplements to the present curriculum would also be a poor use of the technology and its potential for learning. This proposal outlines both a rationale and a process for integrating computers into the District 4-J curriculum.

WHAT DOES IT MEAN TO BE EDUCATED IN AN ENVIRONMENT WHERE COMPUTERS ARE READILY AVAILABLE?

We have created the present curriculum, over a long period, to incorporate several kinds of educational technology that are readily available in schools. Among these extant technologies already incorporated into the curriculum are printed materials, writing tools, and audio-visual components, among others. We are now approaching a new technology that could be incorporated into virtually every level of every subject matter discipline. But this new technology is expensive and requires careful planning if students are to get the benefit of its best use. The proposed planning and implementation will take from 3 to 6 years, depending on resources available and on the curriculum management cycle.

The appropriate infusion of computers into the curriculum should not be additive, except in the case where entire elective courses will be added at the secondary level. For the most part, however, incorporation into content areas must be done by supplanting existing materials or processes within the established curriculum. The replacing of curriculum elements should only be done where it can be shown that the computer equivalent can provide benefits/results that are clearly superior to the way we now do it. In order to make good judgments about whether the computer is a better vehicle for learning we need to begin examining not the present curriculum, but instead the educational program goals as articulated in the Position Papers developed by each Subject Matter Council over the last two years.

If the planning group can, in effect, look beyond the existing curriculum veneer, and focus instead on established program goals, it will be possible to get at the basic question posed earlier: "What does it mean to be educated", at least for the decade of the 1980's in District 4J. Analysis of these goals by a group which understands computer applications can yield directions for education in an environment where computers are readily available.

I propose that potentially appropriate computer applications be identified throughout the K-12 scope of each discipline's program goals. Once identified, these replacement components would be prioritized by the appropriate subject matter councils in terms of which should be implemented sooner and which to delay for later incorporation. The prioritized lists from all councils would then be reconsidered by the Computer Council and its Coordinator in terms of hardware, software, training, and maintenance implications. The Computer Coordinator would then develop a long term implementation schedule to reflect the aggregate priorities.

COMPUTER SOFTWARE: LEGAL AND ETHICAL ISSUES

David Novick
University of Oregon

I. INTRODUCTION

What is wrong copying other persons' programs if they won't be hurt? People use computers routinely face this and similar questions, but lack a systematic way to find answers. Some writers have proposed a professional code of ethics for computer science. However, for the reasons discussed below, codification of ethics may not the best approach. Given the nature of the field, the origins of our ideas about ethics, and the novelty of the questions we face, a better approach to ethics in computer science may be developed on an evolving, case-by-case basis.

To explore the interaction of ethics and law with respect to computer software, I will look at the role of ethics in computer science, examine the origins of moral authority in science, and explore the question of whether there are any difficult issues in the field at all. I will then turn to three specific problems where, if the problems are not "morally hard", the roles of law and ethics are at least unclear. I intend that as a result of performing these analyses, users will gain some measure of skill in dealing with similar problems they may encounter.

II. THE ROLE OF ETHICS IN COMPUTER SCIENCE

A. Definitions

Morality: moral science (in the sense of knowledge); moral principles; points of ethics; particular systems of morals.

Moral: concerned with character or disposition, or with the distinction between right and wrong; thus, moral sense: the power of distinguishing right and wrong.

Ethics: science of morals; moral principles; rules of conduct; the whole field of "moral science".

Etiquette: conventional rules of personal behavior in polite society; unwritten code restricting professionals in what concerns the interests of their co-professionals or the dignity of their profession.

As these definitions, collected from dictionaries, do not bring great clarity, I propose to distinguish, in this paper, between morality as a measure of absolute goodness in some natural sense and ethics as a system or collection of precepts based on morality. In other words, morality is our knowledge of what is good, and ethics are systematic ways of resolving conflicts between competing goods.

B. Origins of Moral and Ethical Authority in Science

Philosophers in the Anglo-American political tradition have postulated different bases for morality, which give rise to correspondingly different ethical systems. Thomas Hobbes believed that there was no absolute good or evil; as a result, a sovereign's rule was necessary to provide unambiguous standards for conuct. Sovereign decision, however, does not easily square with our present ideas of individual choice and rejection of autocracy. Moreover, rules imposed by a sovereign

must be codified in order to provide prospective guidance rather than post-facto retribution. In the context of a rapidly changing technology like computer science, the Hobbesian view seems unrealistic.

The notion that moral authority must arise from a sovereign was rejected by the Moral Sense School. In this view, all people have an innate sense of right and wrong. Thus, the "natural" sense of what is right and wrong provide a sort of universally-accepted guide to moral behavior. Aside from its other, philosophical difficulties, the view of the Moral Sense School suffers from a serious problem in the context of computer science: The reason one looks at morals in computer science is that one is facing unforseen choices; if everyone had a sure sense of right and wrong in this regard, there would be no question to trouble us. Jeremy Bentham proposed to solve this problem by "scientifically" evaluating measures of goodness. That is, the "objective" societal value of an act would determine its morality. Even though we live in an era which, compared with Bentham's, accepts science and technology as part of daily life, we can quickly see that the Utilitarian scheme would not be practical.

A more contemporary thinker, Oliver Wendell Holmes, Jr., also embraced scientific standards as a basis for societal order. However Justice Holmes felt that law, rather than morality, should be the focus of such inquiry. In looking at morality, Holmes proposed that social, basic norms should define the bounds of moral behavior. In this view, no sovereign need impose a moral order because the authority of a norm is delegated from the norm itself. That is, the set of values which we

collectively hold as moral is effective because it is imbued with a political legitimacy. In Holmes's terms, an indefinite body may be a source of law. Similary, an indefinite collection of norms may be a source of morality.

C. Difficult Ethical Issues in Computer Science?

Given even these sketchy thoughts, it would seem to be hard to construct a morality of computer science, let alone a system of ethics based on such a morality. There are, however, certain things upon which we can probably agree: it is wrong to injure someone; curiousity is good; putting knowledge to work is good; and so forth. One might object that "curiousity is good" (or any of the other tenets above) is not always true. This objection, I believe, is ill-founded because it confuses morals and ethics. That is, situations where one might like to inhibit curiousity arise not because the curiousity is itself bad but because some other moral value, perhaps privacy, seems more important under the circumstances. Given a set of agreed moral values (or, to put it another way, goals), we are faced with the problem of resolving situations where moral values conflict. This is what I have been referring to as Ethics.

Using this definition, there are obviously a large number of ethical decisions to be made in computer science and computer education, but it is not obvious that any of these decisions are difficult ones. In medicine, by way of contrast, there are clearly difficult ethical decisions; for example, our moral sense that life should be preserved conflicts with our sense that persons should be spared misery when facing the plight of a terminally ill person in much pain whose life is being

sustained through "heroic" efforts. Similarly difficult questions exist in other professions such as law. In the sciences, and in scientific education, there has been little clamor for guidance on questions of similar difficulty. A survey of formal ethics in the sciences conducted in 1981 found that the few ethical codes which did exist were typically promulgated by engineering societies, that the codes had a fair amount of formality, and that there was neither widespread dissemination or acceptance in the scientific community. My own review of proposed codes of ethics in computer science suggests that such codes are chiefly concerned with upholding the dignified image of the profession which computer programmers aspire to create.

There are, nevertheless, some interesting issues resulting from moral conflict in the use of computers. The most troublesome to those seeking to do research is a variant of the common means-end conflict about improper or distasteful sources of funding. Conflicts between the value of utility versus the value of an orderly society arise in the case of theft of software, copyright violations, and invasion of privacy. The value of curiousity is clearly at odds with the value of privacy in many situations, including the creation and use of large databases. In some of these cases there are laws which provide relatively clear guides for behavior independent of ethical considerations. In other situations, the law is obscure or non-existent. In the last part of this paper, then, I propose to look at the interaction of ethics and law in three specific situations which I believe are commonly encountered by computer educators.

For further reading on the general questions of morality and ethics in science, I suggest the following works:

Benjamin, A. Cornelius. Science, Technology, and Human Values. Columbia, Missouri: University of Missouri Press, 1965.

Frank, Philipp. Philosophy of Science: The Link Between Science and Philosophy. Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1957.

Hall, Everett W. Modern Science and Human Values: A Study in the History of Ideas. Princeton, New Jersey: D. Van Nostrand Company, Inc., 1956.

Prior, Moody E. Science and the Humanities. Evanston, Illinois Northwestern University Press, 1962.

Weingartner, Paul, and Zecha, Gerhard (Eds.). Induction, Physics, and Ethics: Proceedings and Discussions of the 1968 Salzburg Colloquium in the Philosophy of Science. Dordrecht, Holland: D. Reidel Publishing Co., 1970.

III. INTERACTION OF ETHICS AND LAW ABOUT SOFTWARE

A. Illicit Copying And Use of Software

Trade secret protection, a creation of state common law, has been frequently cited as the best method for protection of the ownership interest in computer software. Aside from the problems which otherwise limit the effectiveness and scope of this doctrine, it seems totally inapplicable to the use of software in education. That is, educational use is, virtually by definition, the sort of public use or distribution which renders trade secret protection impotent. As a result, most educators encounter the problem of illicit copying and use of software in the context of the federal copyright laws. The present law, the Copyright Act of 1976 (as amended), is encoded at 17 USCA. Under the copyright law, a computer program (or any other work, for that matter) can be copyrighted as soon as it is in a "fixed" form. This means that a program can be copyrighted when it is written or typed on paper, stored on disk or tape, or otherwise

stored in a manner in which the program may be read by a person or a machine. The authors' expectations that the program will later be revised or expanded does not affect the copyrightability of the program. Rather, the authors can subsequently copyright the changes and additions as they are made. Thus if as an educator you are writing a computer program, you will probably want to obtain copyright protection for the program as soon as you create it. Note that the length of protection for programs which are jointly created is the life of the longest-surviving author plus fifty years. However, where you are an educator who wishes to use a program, your interest is in wide use of a work rather than its protection. The copyright laws provide a relatively mechanical solution to this problem: the competing values of encouraging new works and fostering widespread use have been resolved without requiring educators to make ethical choices. The reality, though, is that the ethical values of these solutions have to be communicated to students; respect for federal law may not be enough, particularly when the institution or some of its employes violate the copyright law as a matter of routine.

Legally speaking, a copyright is just that: the exclusive right to make copies of a computer program or other work. The copyright act provides that the owner of a copyright has the exclusive rights to do and to authorize any of the following things:

1) to reproduce the program in copies;

2) to prepare derivative works based upon the program;

3) to distribute copies of the program to the public by sale or other transfer of ownership, or by rental, lease, or lending. There are also some other rights which mainly involve non-computer works, such as plays and movies. That these rights may also have a basis in the extra-legal societal norms upon which the law is based, then, constitutes the ethical aspect of illicit copying and use.

B. Unauthorized "System Hacking"

Similarly, there may be few laws regarding the consequences of unauthorized access to a computer system, but we have, I suggest, a common fund of understanding that this is something wrong. The hacker may get some educational value out of this activity, but the wrong created thereby is usually deemed greater than the good. Should this decision be left to the individual, or should a generally accepted sense of the bounds of such activity be organized?

C. Collection, Use, and Maintenance of Information

The creation of databases large and small, in schools, business, and government, have given rise to articulated fears that misuse of these databases might infringe on privacy interests. Invasion of privacy is, in this country, overwhelmingly a matter of state common law. The rules thus vary enormously by state; indeed, the right itself was not even recognized until the turn of the century. In the case of databases, the common law has yet to catch up to our technology. Should the moral values of (non-legal) privacy outweigh the utility of the use of information, in the absence of a rule of law?

For more information on the growing field of computer law, I suggest turning to these books:

American Bar Association. Sorting Out the Ownership Rights in Intellectual Property: A Guide to Practical Counseling and Legal Representation. American Bar Association, Section of Patent, Trademark and Copyright Law, 1980.

Brooks, Daniel T. (Ed.). Protecting, Acquiring, and Marketing Computer Software for the Mass Market: Effective Legal Strategies. New York: Harcourt Brace Jovanovich, 1982.

Brooks, Daniel T., and Gilburne, Miles R. (Eds.). Contesting Computer Disputes: Litigation and Other Remedies in Contract, Trade Secret and Copyright Cases. New York: Harcourt Brace Jovanovich, 1981.

Brooks, Daniel T., and Keplinger, Michael S. (Eds.). Computer Programs and Data Bases: Perfecting, Protecting and Licensing Proprietary Rights After the 1980 Copyright Amendments. New York: Harcourt Brace Jovanovich, 1981.

Mandell, Steven L. Computers, Data Processing, and the Law. St. Paul, Minnesota: West Publishing Co., 1984.